MECHANICAL DRAWING

HUTTON

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MECHANICAL DRAWING

FOR INDUSTRIAL AND CONTINUATION SCHOOLS

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EDITOR'S NOTE

In commercial shop and construction work a mechanically drawn plan invariably accompanies the work of construction. Such a plan is the chief means of giving information to mechanics concerning work to be done. Upon their ability to read and properly interpret these drawings will depend the accuracy of construction and the proper assembling of parts.

In learning a trade under ordinary commercial conditions only incidental practice is afforded in reading drawings. Experience has shown, however, that when such practice is an integral part of trade instruction, proficiency in tool operations comes more quickly and surely.

One of the most satisfactory methods of learning to read drawings is to make them. Hence it is desirable in the preparation for industrial pursuits that students be given a simple and practical course in mechanical drawing

The Author has, as a result of his experience in trade work and industrial teaching, prepared a text which is peculiarly suitable for use in continuation, all-day industrial, and evening classes. It is well arranged to enable those interested in a particular trade to become familiar with essential drawings, and to learn how to make them quickly and accurately.

These characteristics should recommend the book to those in charge of industrial work in schools, including high schools.

F. D. Crawshaw.

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PREFACE

The arrangement of the following course is the outgrowth of several years of experience in teaching the subjects of Mechanical Drawing and Industrial Arts to boys of the intermediate grades.

Since the organization of Industrial Departments in the schools of Chicago, the author has taught an average of one hundred boys per day and has given his whole time and attention to Mechanical Drawing.

Having had years of experience as a practical wood-worker and mechanical draftsman, he has applied this practical experience to the school room. He has endeavored to make drafting interesting by making it practical.

Exercises and fundamental and essential conventions have been combined in practical problems suitable for those engaged in various lines of industrial work. These follow an *elementary course on principles which should be mastered by all beginners.* The special industrial courses following the elementary course may be taken with profit by all. However, beginning with SHEET METAL WORK, each course is prepared with reference to peculiar industrial interests. Up to this point the work, as outlined, should be regarded as a unit.

The purpose of the author has been:

(1) To arrange a course especially adapted to, and within the limit of, a boy's ability.

(2) To give the boy an intelligent idea of what a mechanical drawing is for, how to make it, and how to read and work from one made by others.

(3) To awaken an interest in the common industries of life, and to create a desire for as complete an education along industrial lines as possible.

If the boy is to enter industrial life at an early age, the course in drafting herein outlined will give him a foundation for his life duties far beyond that of the average mechanic.

The course is both logical and practical.

PHILIP W. HUTTON.

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INTRODUCTION.

A mechanical drawing is an assembly of views of an object which show the length, width, thickness, and form of each and every part of it. By means of dimensions and notes, the size of each part and the material of which it is to be made are given. In fact, a mechanical drawing gives all the details about an object which a workman or series of workmen may need in its construction.

Mechanical Drawing may be classed as a universal language by which the designer of an object can, through a drawing of it, transmit his ideas clearly to the man or men who are to make it.

In the construction of a building, or a bridge, the foundation is first laid. So it is in the study of Mechanical Drawing. The use and care of all drawing tools must first be thoroughly understood. After this, some general principles must be mastered. These principles will not be given all at once, but will be introduced from time to time as a need for them arises in the different problems to be worked out.

After the foundation is laid, certain fundamentals must be given consideration, such as the work an object has to perform, the use to which an article is to be put, etc. These fundamentals are effected by:

(1) The most suitable materials for strength, wearing ability, etc., to perform the desired work.

(2) The construction to be used.

(3) The design or shape, so as to make the object pleasing to the eye and still to allow it to perform its work.

EQUIPMENT

The necessary equipment consists of the following:

1 Drawing Board
1 T-Square
1 30-degree 60-degree Triangle, 8″
1 45-degree ” 6″
1 12″ Rule graduated to sixteenths.
1 Irregular or French Curve
1 Protractor
1 Soft red rubber Eraser
1 Ink Eraser
1 Cleaning Eraser
½ dozen Thumb Tacks
1 3H Pencil
1 4H Pencil
1 12″ Triangular Scale Rule
1 Penholder
½ dozen fine pointed Pens. (Gillotts No. 303)
1 Bottle Drawing Ink

1 Drawing Set consisting of the following:

  1 Compass with Lengthening Bar, Pencil, and Pen Points
  1 Divider
  1 Bow Divider
  1 Bow Pencil
  1 Bow Pen

DESCRIPTION, CARE, AND USE OF TOOLS

The selection and care of drawing tools and instruments must be given careful thought and consideration.

DRAWING PENCILS

By referring to the equipment list it will be seen that two pencils of different degrees of hardness are required. The degree of hardness is designated by the number of H's stamped on the pencil. Experience has taught that the HHH and the HHHH, in other words the three H and four H pencils, are best fitted for use in beginners' hands. The more H's the pencil has the harder the lead is; the four H pencil is, therefore, harder than the three H. The three H pencil sharpened to a long round point (Fig. I) is used for all freehand work, such as the making of arrow points, figures, etc. The four H pencil sharpened to a long wedge-shaped point (Fig. I) is used for all line work such as light construction lines, dimension lines, object lines, and dotted lines. Care must be taken not to apply so much pressure on the pencil that it will cut the paper.

Figure I, which shows the proper and improper sharpening of the pencil, should be given careful examination. A pencil cannot be properly sharpened with a dull knife, and the knife, however sharp, should never be employed for anything except the whittling away of the wood. Allow about ¼″ of the lead to project from the wood after whittling, and by the aid of fine sand paper, or a fine file, shape the lead properly, as shown in the illustration.

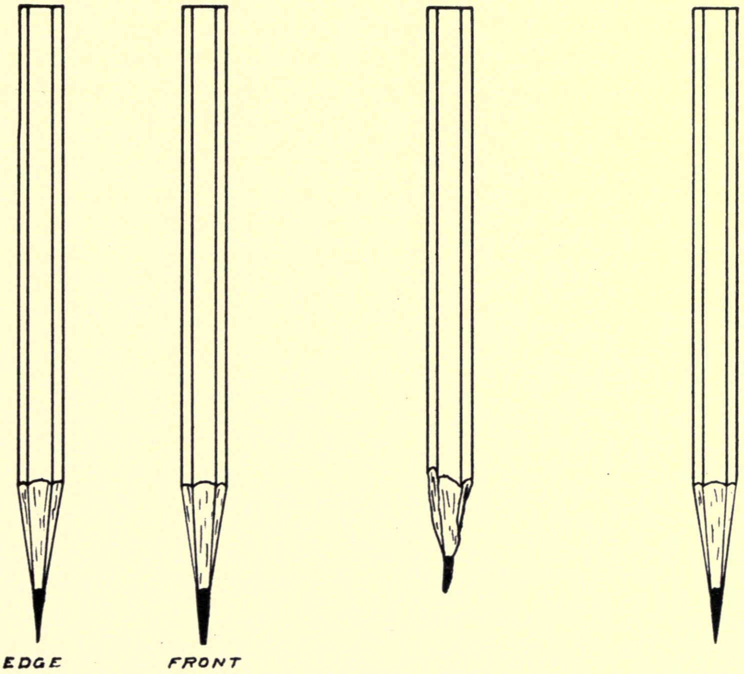
ERASERS

Very little needs to be said on the use of Erasers. Each student should be provided with one soft red rubber eraser for the removal of pencil lines, one eraser containing a gritty substance for removing ink, and one cleaning eraser such as art gum for removing dirt, finger marks, etc., from the paper.

THUMB TACKS

Thumb Tacks are used to hold or fasten the paper in its proper position on the Drawing Board. A tack with a round tapering pin and 5/16″ round oval head is best. With careful use half a

FIG. I



4 H PENCIL PROPERLY SHARPENED FOR LINE WORK

WRONG WAY FOR ANY WORK

3 H PENCIL WITH ROUND POINT FOR LETTERING

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dozen tacks should be sufficient. The tacks should never be driven in with the T-Square or any other instrument, but should be pressed in with the ball of the thumb. As the Drawing Board is constructed of soft pine, this operation is not at all difficult.

Care should be exercised in the extraction of thumb tacks. If they are pried out by placing an instrument under the edge, the stem is very apt to bend, and after a few such operations it will break off. The simplest way to extract a thumb tack is to grasp the edge of the head with the nails of the thumb and middle finger, at the same time twisting the tack to the right and left. It will be found that this loosens it so that it can easily be pulled straight out, since the action applies no leverage or side motion. This method greatly increases the life of the tack.

INK

It is advisable not to purchase the drawing ink until the time arrives for ink work to be taken up, for ink, unless it is in a perfectly airtight bottle, evaporates quickly. A black water-proof drawing ink of any standard make will answer.

PENS

A fine-pointed steel pen such as the Gillott No. 303 or its equivalent must be used for arrow points, figures, etc. The pen must be wiped thoroughly after using and before the ink dries, or its life will be of short duration.

THE PROTRACTOR

The Protractor is an instrument used for measuring and laying off angles (Fig. II, p. 13). It is semicircular in shape and is usually graduated in degrees and half degrees. In laying off or locating an angle, the point on the Protractor representing the horizontal center (A) is to be placed on the vertex point of the angle, or the place where the vertex of the angle is to appear. The horizontal line (B) on the Protractor should coincide with the base line of the angle (C) as shown in the illustration. The number of degrees to be found or located can then be read off on the semicircular or graduated edge (D) of the Protractor.

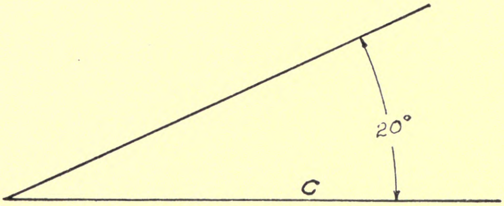
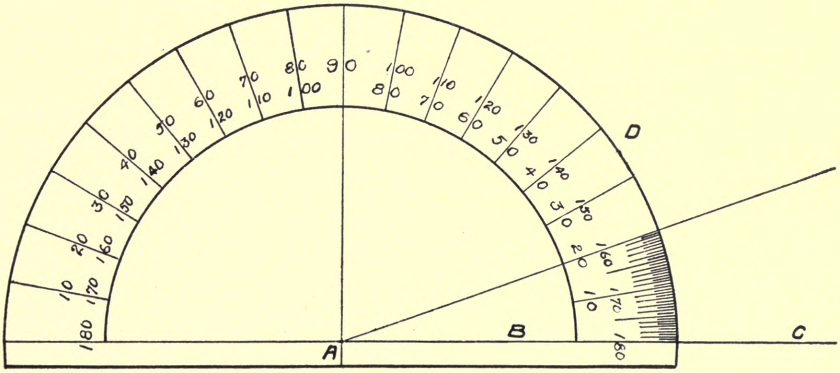


FIG. II



PROTRACTOR

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THE IRREGULAR CURVE

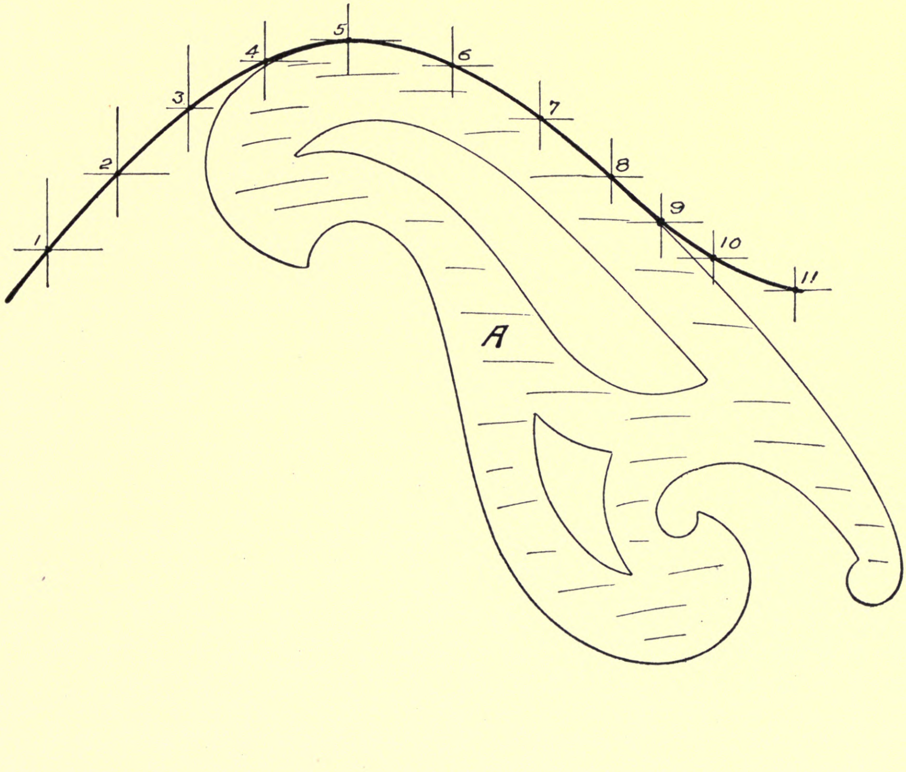
The Irregular or French Curve (A, Fig. III) is an instrument used for the construction of lines which are not straight but which cannot be drawn with a compass. In the construction of such lines, points should be located in the direct path of the line 1, 2, 3, 4, etc. (Fig. III). After these points have been located the curved line must be drawn, a little at a time. In this process the edge of the Irregular Curve (A) is used as a guide. To insure perfect results the edge of the Irregular Curve must pass through at least three points at each setting and as many more points as possible. If the curve to be constructed is of considerable length, adjust the Irregular Curve so that the edge of it will pass gracefully through three or four points, and draw this section; then, using the last two points in the section just drawn as a guide, readjust the Irregular Curve so that it will pass through these last two points and as many new points as possible. Continue this process until the required curve is completed.

Both the Protractor and the Irregular Curve should be made of a transparent material such as is used for the Triangles.

THE RULER

The Ruler best adapted to Mechanical Drawing work is the beveled edge type, 12″ in length and graduated to sixteenths (B, Fig. IV). The Ruler is used only to determine distances. It is not intended to be used as a guide for drawing lines. The T-Square and the Triangles are for this purpose, as will be explained later.

FIG. III



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THE SCALE RULE (A, FIG. IV)

The principle involved in the Scale Rule is very puzzling to the beginner, but he will see clearly its use and advantage by giving strict attention to the following explanation.

Let us suppose that we are to make the drawing of a certain object, the length of which we will say is nearly twice that of the paper on which it is to be drawn. How can we accomplish this? It should occur to us at once that the object must be drawn half its actual size. Let us analyze what this means. We have practically, as far as this individual drawing is concerned, reduced the size of our rule just one-half. In other words a 6″ measurement on our half-size drawing equals a 1′ measurement on the object being drawn. Our drawing, then, if made to a scale of 6″ equals 12″, or 1′ (commonly called scale 6″ = 12″), will be one-half size.

Suppose that we are required to make a drawing of a building 100 feet in length, and that we have a piece of paper just 30 inches long on which to represent or draw this building. If we were to draw it full size it would require a paper 100 feet in length. If we were to draw it half size it would require a paper 50 feet in length. So, knowing that the size of our drawing must be within the limit of 30 inches, we must look for a scale on our Scale Rule that will meet the requirements. Let us say we will make our drawing to a scale of "¼″ equals 1′." It can be readily seen that, drawn according to this scale, our building will be just 25″ long on paper. On your triangular Scale Rule you will find spaces as follows:

3 inches long representing 1 foot.
1½ ” ” ” ”
1 ” ” ” ”
¾ ” ” ” ”
½ ” ” ” ”
⅜ ” ” ” ”
¼ ” ” ” ”
3/16 ” ” ” ”
⅛ ” ” ” ”
3/32 ” ” ” ”

You will find, also, a regular 12″ Rule divided in inches, halves, quarters, eighths, and sixteenths.

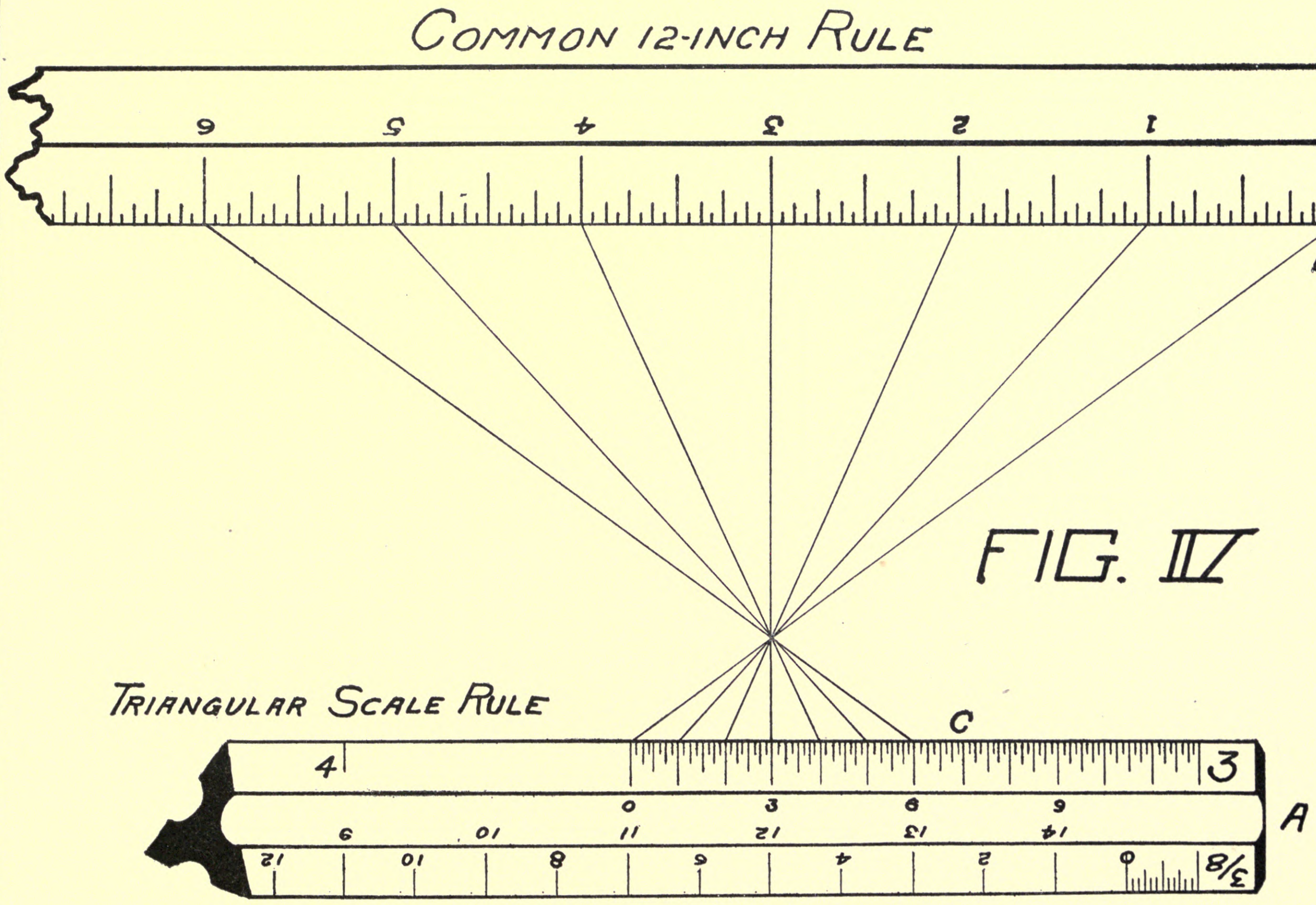

FIG. IV

SHOWING DIRECT COMPARISON INCH BY INCH OF A COMMON 12-INCH RULE WITH THE 3-INCH SCALE ON A TRIANGULAR SCALE RULE

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Now notice the 3″ scale (C, Fig. IV) and you will see that it is divided into twelve equal parts; therefore at a scale of 3″ to the foot, each one of these divisions equals 1″. The 1″ space is divided in the center by a long line; this makes two shorter spaces each representing the half of 1″, or ½″. The ½″ space is divided by a line not so long, which makes two still shorter spaces each representing the half of ½″, or ¼″. This ¼″ space is divided by a line shorter than the rest and represents a distance of ⅛″.

It will be seen, therefore, that the 3″ space (C, Fig. IV) thus divided is nothing but a miniature 12″ rule in exact proportion in every way. So it is with every scale shown on the Scale Rule. They are all miniature 12″ rules, but they are not all divided to ⅛″, for if they were the divisions would be so small they could not be read. Look at the ⅛″ scale and see how small the divisions are. Each small division on this scale represents 1 inch.

Now let us turn our rule so that we again have the 3″ scale before us. From the 3″ scale, reading to the left, you will find in the groove the figures, in their order—0, 1, 2, etc.—which mean that the distance from the 0 to the figure 2 represents 2′ on the scale of "3″ equals 1′." Suppose we wish to step off a distance of 2′ and 6″ on this scale. From the 0 to the right in their order and in the groove you will see the figures 0, 3, 6, 9. So the distance from the figure 2 at the left of the 0 in the groove to the figure 6 at the right of the 0 in the groove will be an exact measurement representing 2′, 6″ at a scale of "3″ equals 1′."

By dividing 12″ by 3″ we find that in drawing the object to a scale "of 3″ equals 1′," we will have the drawing when finished, exactly ¼ size. Drawing an object ¼ size without the use of a Scale Rule would require considerable time in figuring for each dimension. Moreover, the possibility of making a mistake would always be on the draftsman's mind, which would take his attention from his work. Later, as a matter of practice, so that you will become familiar with the Scale Rule in all its details, you will be required to draw a series of lines all of different lengths and to different scales.

When you arrive at the part of the work which requires this, review very carefully all that has been said about the Scale Rule. In this review keep the Rule itself constantly before you for reference.

DRAWING BOARD

The first tool with which we come in contact is a Drawing Board. The kind and size of board to purchase depend largely upon the future use to which you intend to put it. If you contemplate High School or University, a board of considerable size would be advisable. If a board is not furnished by the school, ask the advice of your teacher as regards the size. Any board chosen should be constructed of select dry white pine properly reinforced to prevent warping.

DRAWING SETS

A Drawing Set containing the variety of tools specified in the equipment list can be purchased at various prices according to the quality and amount of material and workmanship expended on them. A medium priced set will, with proper care, last for a number of years.

A set constructed with all center points removable is, when considered from a standpoint of accuracy and durability, advisable. Any set purchased must be kept bright and clean. Ink must never be allowed to dry in the pens as this corrodes the metal and causes a roughness which naturally interferes with the proper flow of the ink. When the pens are not in use be sure that the adjusting screw is set so that the pen points are open. If the pens are laid away with adjusting screw run up tight so as to place considerable tension on the pen blades it will be found in time that the natural spring of the blades will be lost and that the pen will be rendered useless.

The individual use of the drawing instruments will be taken up as the use for them arises in the different exercises, problems, etc.

T-SQUARE

The T-Square consists of head and blade (see Fig. V, p. 21). The inside edge of the head and both edges of the blade must be perfectly straight and free from nicks, and the head and blade must be set permanently at an angle of 90 degrees to each other. The blade of the T-Square should not be shorter than the length of the Drawing Board.

TRIANGLES

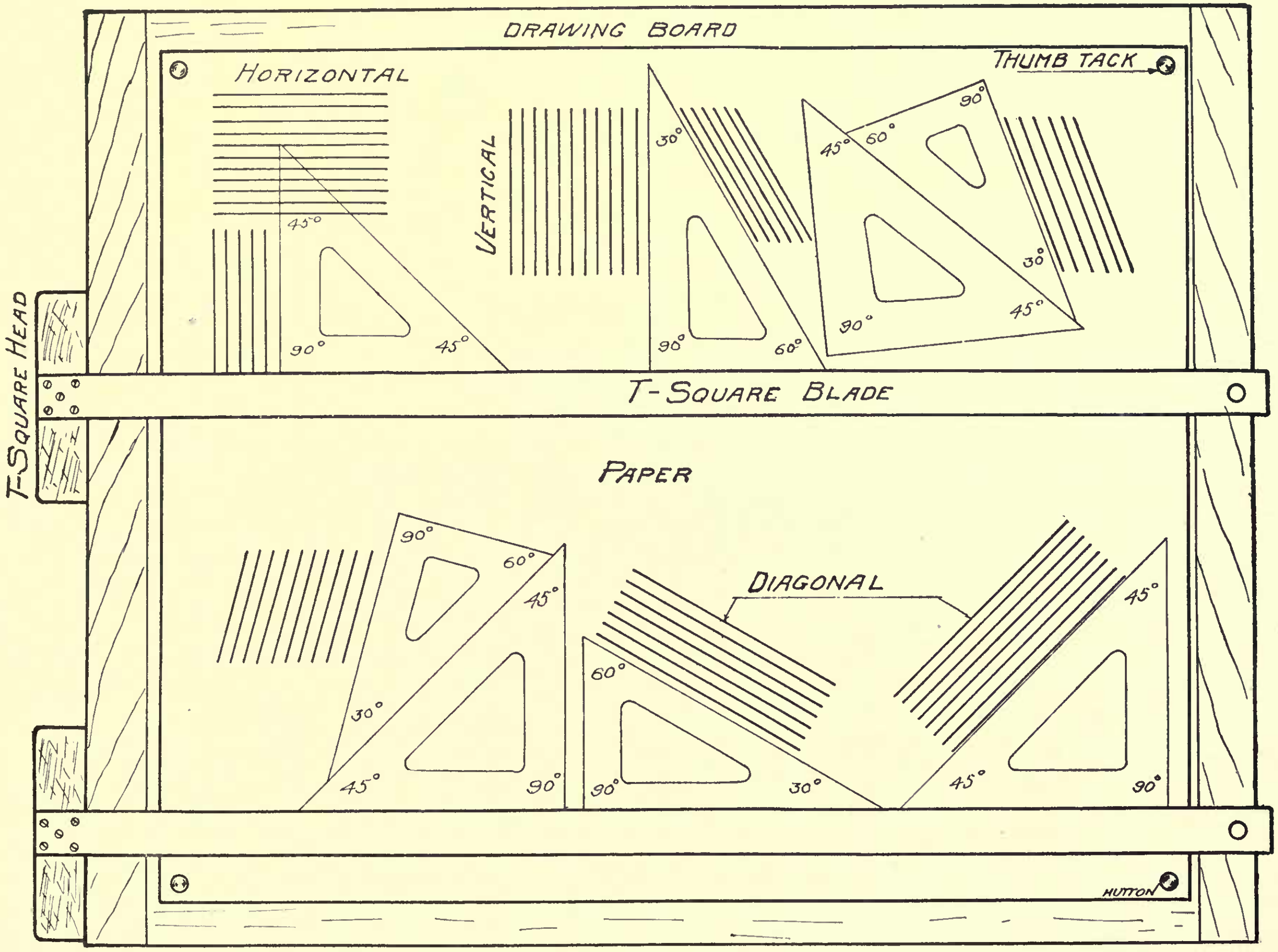
The Triangles (see Fig. V) are two in number, one of which is commonly called a 45-degree and the other a 30-degree Triangle. These tools are, as the word triangle implies, three-cornered. The 30-degree Triangle has one corner which measures 30 degrees, or the twelfth part of a circle, one 60 degrees, or the sixth part of a circle, and one 90 degrees, or the fourth part of a circle. The 45-degree Triangle has two corners, each of which measures 45 degrees or the eighth part of a circle, and one which measures 90 degrees.

Both Triangles should be made of a transparent material such as celluloid. They are to be used in connection with the T-Square.

HORIZONTAL AND VERTICAL LINES

All horizontal lines (see Fig. V) are drawn by using the upper edge of the T-Square blade as a guide for the pencil. All perpendicular or vertical lines are drawn by using an edge of one of the Triangles as a guide for the pencil. In order to get proper results and to have all horizontal lines parallel, the head of the T-Square must be used in direct contact with the left end of the Drawing Board. Much care must be exercised in this, for if the full length of the inside edge of the T-Square head is not firmly pressed against the left end of the board, corresponding lines on the drawing will not be parallel. The top edge of the T-Square blade is used also as a base for the Triangles. The edge of the Triangle perpendicular to the T-Square blade is used as a guide for the pencil in drawing vertical lines. Therefore, it should be readily seen that the foundation guide for vertical lines as well as horizontal lines is the T-Square head in contact with the end of the Drawing Board (see Fig. V). This is a fundamental principle which must be mastered. It can be done quickly if the directions given are carefully followed.

FIG. IV


DRAWING BOARD
HORIZONTAL
THUMB TACK
VERTICAL
45°
90°
45°
30°
90°
60°
45°
60°
90°
30°
45°
90°
T-SQUARE HEAD
T-SQUARE BLADE
PAPER
DIAGONAL
90°
60°
45°
30°
45°
90°
60°
90°
30°
45°
45°
90°
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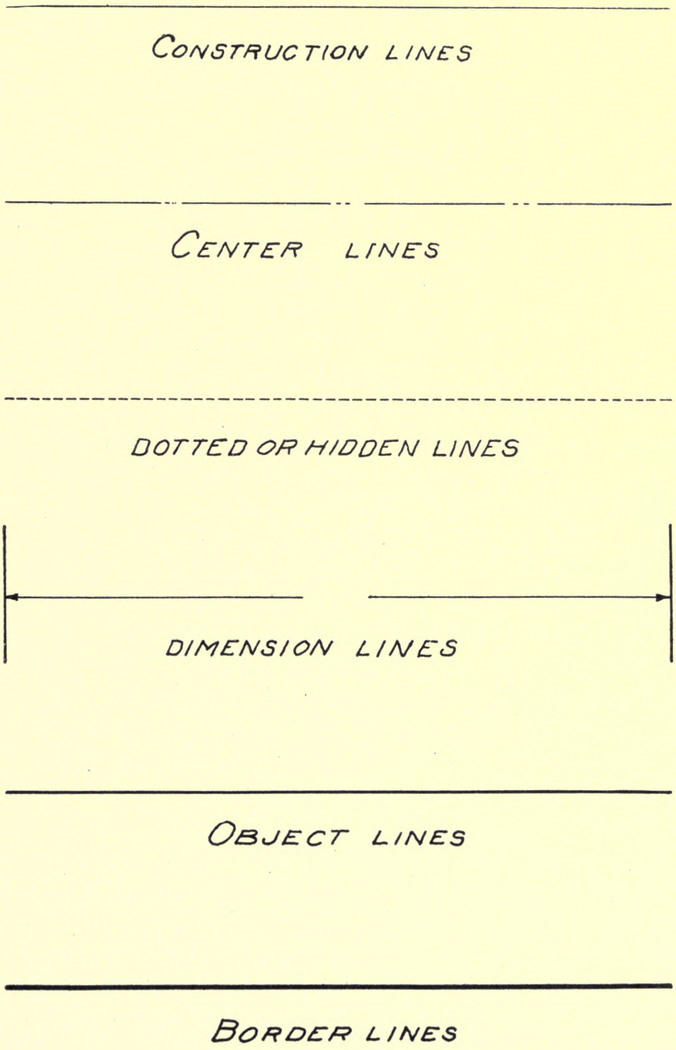
LINES TO USE

Examine carefully the several different kinds of lines used (Fig. VI). When inked in, the construction, the dimension, center, and dotted lines should be much lighter than the object line, yet heavy enough to be distinct. The dimension line consists of two long dashes with space between them for the dimension, or distance between arrow points, as shown. All arrow points must be small, narrow, and solid black. The wide, uneven arrow point is to be avoided. Points of the arrows must touch the lines, the distance between which is represented by the figure. To extend the arrow points through these lines or to place them away from the inside of these lines is absolutely incorrect.

The center line is constructed the same as the dimension line with the exception that two short dashes are placed in each space between the long dashes. Center lines are used, as the name implies, to represent centers of objects or parts of objects. At times the crossing of two center lines represents the location of centers of circles or parts of circles. The dotted or hidden line as shown is used for representing that part of an object which lies behind the surface. When inked the object line must *correspond in thickness* with the object line shown in Figure VI.

FIG. VI


CONSTRUCTION LINES
CENTER LINES
DOTTED OR HIDDEN LINES
DIMENSION LINES
OBJECT LINES
BORDER LINES

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LETTERING

After the proper drill on the construction of different kinds of lines has been had, it will be found easy to construct guide lines for letters as shown in the examples of alphabets and illustrated as construction lines in Figure VII, p. 25. If the illustrations are studied attentively little need be said on the subject. Notice carefully the different steps taken in constructing the letters that make up the word Chicago (Fig. VII). Draw horizontal construction lines representing top, center, and bottom of letters. Space off all letters to be drawn (A, Fig. VII) with the Bow Dividers. Draw your slant lines mechanically, as illustrated in Figure I, page 26, and mark each space with the letter it is to develop into, as shown at B (Fig. VII). Brighten all horizontal lines for letters (C). Brighten all vertical lines for letters (D). Draw in and brighten all other lines as the bar of the G, the side of the A, etc. (E). Erase all construction lines so that the word will be neat and clear as at F. Some letters, on account of their peculiar shape, require a little diversion from the ordinary rule, as A, B, K, M, V, W, etc., shown in Plate, page 26. Note their peculiarities and construct them accordingly. All mechanical lettering is to be done as just described.

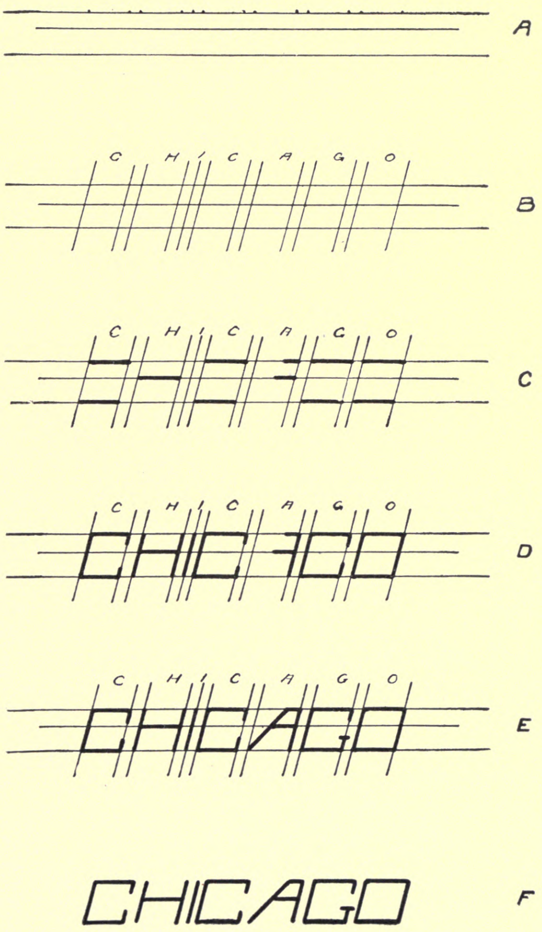
In the small letters, which are made freehand, draw first the guide lines, top and bottom. The distances between the guide lines should correspond with those shown on Plate, page 26.

Considerable practice is required before one can letter properly, either mechanically or freehand. The letters must all be the same in height and in case of slant letter the slant should be uniform. As an aid in making all freehand letters the same slant, place your arm so that its slant relation with the guide lines is the same as the desired slant of the letter. Make sure that all letters touch both top and bottom guide lines and construct them so that they will be a little wider than they are high. Always keep an even space between letters and double this space between words.

All lettering given is of a simple type. Good results will be easily obtained through practice if directions are followed. As good lettering is essential to the neat appearance of a drawing there should be practice in lettering whenever an opportunity presents itself. It may be well, under the guidance of the instructor, to prepare a formal sheet of letters.

NOTE. If it is so desired, a special angle for lettering only can be constructed as shown in Figure II, Plate, page 26.

FIG. VII



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EXAMPLES OF ALPHABETS

LETTERS 1/4" HIGH 1/4" WIDE

ABCDEFGHIJKLMNOPQRSTUVWXYZ

ABCDEFGHIJKLMNOPQRSTUVWXYZ 3/32"

1234567890 3/32"

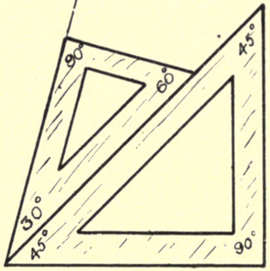

FIG. I

SHOWING METHOD OF LOCATING SLANT

ABCDEFGHIJKLMNOPQRSTUVWXYZ

ABCDEFGHIJKLMNOPQRSTUVWXYZ 3/32"

1234567890 3/32"

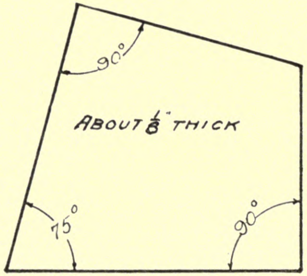

FIG. II

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DRILL IN USE OF INSTRUMENTS

Before attempting any of the exercises a short drill on the proper method of fastening a sheet of drawing paper to the drawing board by means of thumb tacks will be necessary. After the pencils have passed the inspection of your teacher proceed to fasten a piece of paper, size 9″ × 12″ on your Drawing Board by the aid of thumb tacks. Observe strictly the following method, as it is practical, simple, easy, and correct.

Place the paper, a good quality for drawing, in the center of the Drawing Board and with the ball of the thumb press into place one thumb tack in the upper right hand corner of the paper. As there is but one thumb tack in place the paper can be easily moved up and down with that corner of the paper the thumb tack has pierced acting as a pivot. Now place the T-Square in position as in Figure V, page 21, with the head of the T-Square to the left, and the inside of the head held directly and firmly against the end of the Drawing Board. Keeping the head in this position move the T-Square up with the left hand until it is in line with the corner of the drawing paper through which the thumb tack has been passed. With that corner of the paper acting as a pivot, as previously explained, move the paper up or down, as the case may be, until the top edge of the drawing paper is in perfect line with the top edge of the T-Square.

Hold the paper in this position with the hand and press into place one more tack in the upper left hand corner. In pressing the tack into place, care must be taken that it travels perpendicularly to the surface of the Drawing Board, and that the under part of the tack head comes in direct contact with the paper at all points. The contact of the under surface of the tack head with the paper, when the tack is pressed firmly against the board, gives far more holding power than the pin of the tack passing through the paper. If desired, additional tacks may be placed in both lower corners, but for a paper of this size it is not necessary. If tacks are placed in the lower corners of the paper it will cause some inconvenience when drawing in that immediate section, as a rocking motion of the blade is unavoidable when the T-Square is in position and directly over the tacks. Then, too, the T-Square blade is apt to become nicked or marred if it comes constantly in contact with the edge of the tack.

EXERCISES. In selecting the exercises much care has been taken to have a series that not only embraces the proper use of all drawing tools but at the same time presents a pleasing appearance and an interesting set of problems.

It will be found that these exercises bring together and develop the best faculties of the brain, the hand, and the eye, and promote neatness and accuracy. They impress on the mind of the student the absolute necessity of light construction lines. Without the proper and accurate use of the Ruler, T-Square, Triangles, etc., and without pencils sharpened in the proper manner, they cannot be executed. Each exercise should be worked through as described below.

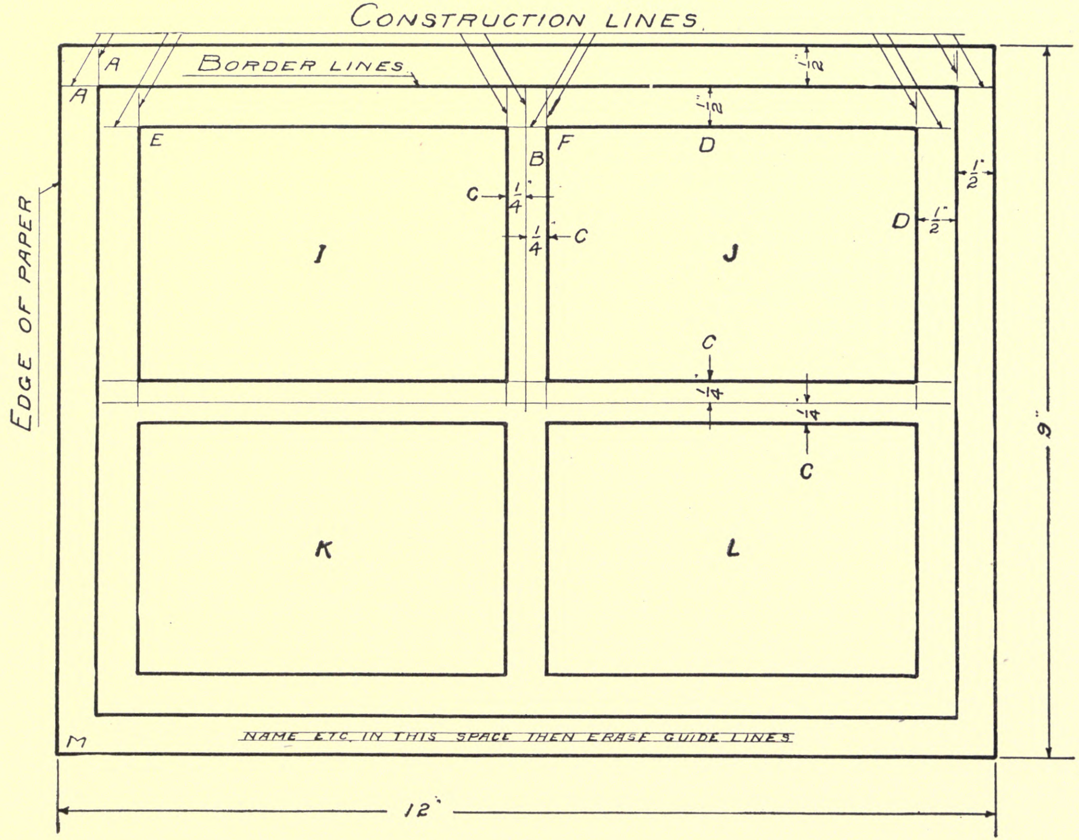
EXERCISE I—LAY OUT OF SHEET

Study Figure V, page 21, carefully. When the paper has been properly fastened to the Drawing Board proceed to construct the border lines. These consist of a horizontal line at the top and bottom and a vertical line on each side (Ex. I, page 29). Each of these lines should be ½″ from the edge of the paper. In drawing each horizontal line, measure the ½″ distance in from the edge of the paper in one place only. After you are sure that the T-Square is held in the proper position, draw the line through this point, with the blade of the T-Square as a guide.

The vertical lines also are to be drawn with but one measurement for each. Use one 90-degree edge of the Triangle as a guide for the line; let the other rest on the T-Square. Make sure, as before, that the T-Square is held in the proper position. (Examine carefully Fig. V, page 21.)

These lines must be very faint construction lines, as it is required that they be gone over or brightened in the spaces between the intersection or crossing of horizontal and vertical lines. The short construction lines which remain at each corner (Ex. I, A) outside of these intersecting points, will later be erased so as to leave a perfect rectangle. If it is found that the paper is not exactly square at the corners, the surplus can be trimmed off when the plate is finished.

EXERCISE I



HUTTON

In the rectangle formed by the border lines will be constructed four smaller rectangles—I, J, K, and L—of the same size, each of which has a space (D) of ½″ around its edges. The first step will be to locate construction lines half way between the border lines in both a horizontal and vertical direction. On each side of each of these construction lines step off a distance of ¼″ (B). This can best be done by adjusting the points of the Bow Dividers to an exact distance of ¼″. Place one point of the Dividers on the line and mark the required distance on each side of it with the other point. Draw in your horizontal and vertical construction lines in the same manner as the border lines were drawn.

Set the points of the Bow Dividers to a distance of ½″ and step off this distance on the inside of each border line as at D. After passing construction lines through the points thus located, brighten up the required rectangles—I, J, K, and L—and erase all projecting construction lines. You now have four perfect rectangles of the same size and with an equal space of ½″ around their edges. Exercise I is shown with construction lines erased from the lower half of the paper. Study this drawing carefully. Read the above again and follow the different steps on the drawing as you read.

You are now ready to fill the four rectangles of Exercise I with dimensions, center, dotted, and object lines. Before attempting this, however, plan carefully the distance apart you wish the lines. Fill one rectangle with dimension, one with center, one with dotted, and one with object lines. In doing this draw some horizontally, some vertically, and some in a diagonal direction. Use a different angle for each rectangle. Care must be taken that all lines are as nearly perfect as possible, and uniformly spaced.

If your plate is not satisfactory, redraw it, write your name, etc., on the back, and lay it carefully away.*

After proficiency in making letters and figures has been obtained, the first exercise can be lettered Exercise I as shown, and with name, age, grade, school, etc., between lower border line and edge of paper. *Never letter directly on the edge of paper or on border line.*

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* A portfolio will be found of great convenience for preserving drawings. One can be made from two pieces of cardboard each about 12″x16″. These should be hinged at one end with ribbons, threaded through holes punched in the proper places, and tied.

EXERCISE II—BASKET WEAVE

Before commencing the construction as shown in Exercise II it will be necessary to prepare a 9″ × 12″ sheet of drawing paper the same as in Exercise I. This time the rectangles are to be filled with the basket weave as shown in Exercise II.

Construct the diagonal weave (Fig. I, Ex. II) in the upper left hand rectangle (I, Ex. I) as follows:

Adjust the points of the Bow Dividers so that they have a spread of exactly ¼″. A good test for their accuracy is to set one point on a ¼″ graduation of the Rule, step off a distance of 2″ or 3″, ¼″ at a time, always keeping one point of the Dividers on the Rule. If the Dividers were set accurately the points will at the end of this distance rest exactly on ¼″ graduations.

When you have your Dividers set with absolute accuracy place one point of the Dividers on the corner (E, Ex. I) of the upper left hand rectangle, (I). Then proceed to the right and divide the top of the rectangle into as many ¼″ spaces as possible. Make sure in this operation that the points of the Dividers at all times rest exactly on, and not above or below, the line. Again set one point of the Dividers at the same starting place, E; proceeding downward, divide the end of the rectangle in a similar manner.

All the points necessary for the spacing of construction lines being located, proceed to draw them as in Figure I, Exercise II. Use the diagonal edge of the 45-degree Triangle as a guide as shown in the lower right hand corner of Figure V, page 21. In this drawing, however, the construction lines to be drawn first must slant in the opposite direction, or in the direction shown at A, Figure I, Exercise II. Proceed to the left, drawing light construction lines through each point located on the end as well as on the top line of the rectangle. With the T-Square in same position reverse or turn over the Triangle and in the same manner draw construction lines in the opposite direction, as in B, Figure I, Exercise II. When this is completed it will be seen that the rectangle is divided into a number of small squares and parts of squares. If the work has been properly executed the construction lines will be so faint that they can hardly be detected—fainter by far than the construction lines shown in Exercise II, Figure I. All the squares ought to be exactly the same in size. If this is not the case the exercise so far as it is completed should be redrawn, as good results are impossible without exactness.

EXERCISE II

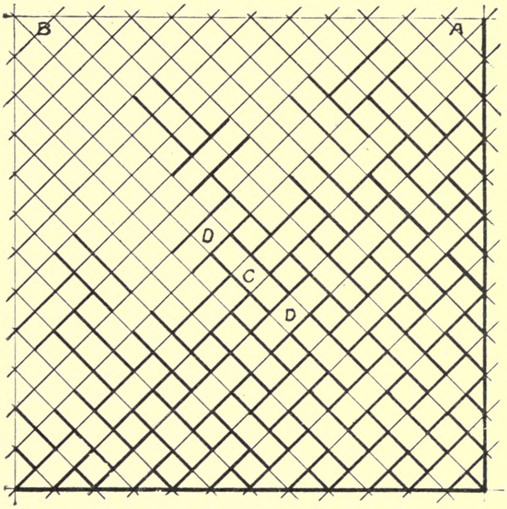


FIG. I

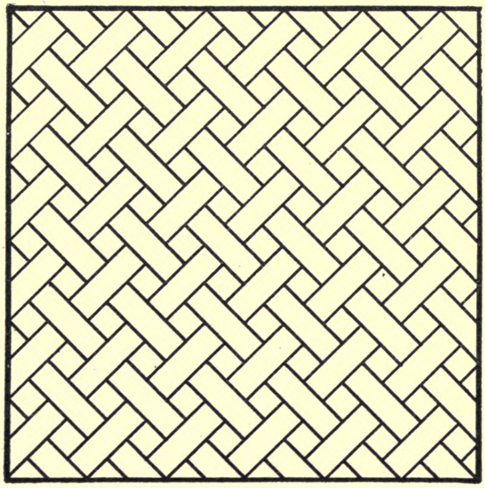


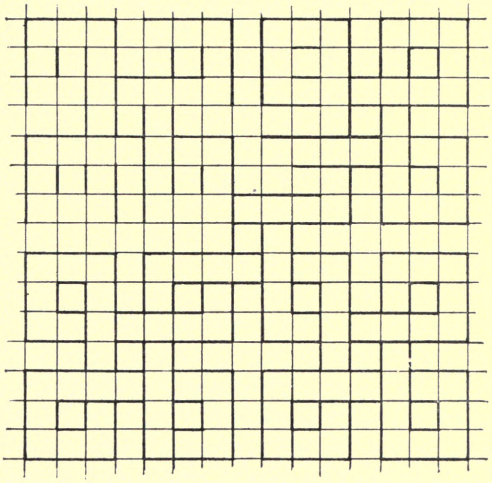
FIG. II

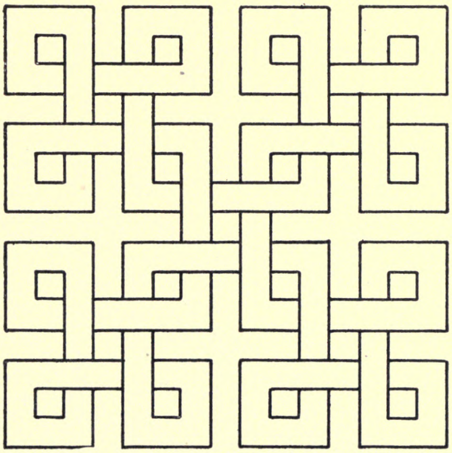
Proceed in the following systematic manner to brighten certain lines which form the over and under appearance of the weave. At any point, as at C, Figure I, Exercise II, brighten a pair of lines three spaces in length. Brighten a pair of lines at right angles to these lines, as at D, thus forming a rectangle, one space wide and three spaces long. Continue this process until the entire space in the rectangle is covered. When the brightening process is completed carefully erase all construction lines as in Figure II, Exercise II. This part of the plate is then finished. Without further explanation proceed to fill upper right hand rectangle, J, Exercise I, in the same manner, except that the size of divisions is increased from 1/4″ to 3/8″ in measurement. This over and under weave appearance can also be executed with horizontal and vertical construction lines, which will give, when finished, a horizontal and vertical instead of a diagonal appearance. Use exactly the same process in the lower left hand rectangle (K), and construct an over and under weave of the vertical and horizontal type with 1/4″ as a standard for spacing. In the lower right hand rectangle (L) construct a vertical and horizontal weave using 3/8″ as a standard. After you have erased all construction lines, etc., print carefully freehand between two guide lines, placed exactly midway between border line and edge of paper (M, Ex. I) your name, age, grade, school, etc. This completes your plate (Ex. II).

EXERCISE III—APPLICATION OF BASKET WEAVE

The principle involved in the construction of Exercise III is the same as that of the square weave, (Ex. II), just finished. For this exercise use an entire sheet 9″ × 12″. First construct the border lines so that you will have a rectangle 8″ × 11″. On the vertical center line between the side border lines and a little toward the bottom of the paper from the center of the sheet, construct with T-Square and Triangle a perfect square exactly 5⅝″ × 5⅝″. Divide the top and one side of this square into fifteen spaces, each space exactly 3/8″. With the T-Square and Triangle as guides draw in the horizontal and vertical construction lines as shown in Exercise III in the top square. Brighten carefully the required lines so as to bring out the design distinctly. Erase all construction lines. Above the design and in the center, print in slant capitals, *EXERCISE III*. Under border line as before print name, age, grade, school, etc. The upper square in Exercise III shows the construction. The student will have one square only on his sheet and that will look like the bottom square in Exercise III.

EXERCISE III





EXERCISE IV—CIRCULAR WEAVE

This Compass exercise requires a combination of horizontal, vertical, and diagonal lines in its construction. The lines just mentioned may be classed as sub-construction lines, as they locate the centers of the circular construction lines that deal directly with the design to be drawn. As in Exercises II and III, Exercise IV has an over and under weave appearance. For this exercise the entire 9″ × 12″ sheet of paper will be needed. On the vertical center line between the side border lines and a little toward the bottom of the paper from the center of the sheet, locate a point. Examine the small or Bow Compass to see that the lead is sharp and that the shouldered* end of the steel center point is out. Run up the adjusting screw of the Bow Dividers so that the lead and the shouldered steel points come nearly in contact with each other. Then adjust these points so that they will be of the same length.

Again by the use of the adjusting screw set the lead and the steel points to an exact distance of one inch. After the Compass is once set accurately it must not be changed during the entire process of constructing or finishing the exercise.

With the steel points set on the center already found, draw a faint circular construction line (1, Fig. I). By means of the T-Square and the Triangle draw horizontal and vertical construction lines A and B so that they pass exactly through the center of the circle (1).

By the aid of the T-Square and the diagonal edge of the 45-degree Triangle, pass through the same center the two diagonal construction lines, C and D. The circle (1) has now been divided into exactly eight equal parts. Use as centers the points where the horizontal, vertical, and diagonal construction lines, A, B, C, and D, intersect or cross the circle (1) and draw eight more light construction circles as 2, 3, 4, etc.

In the construction of this exercise sixteen evenly spaced circles are necessary. So far eight of these have been located. It is evident then that points must be located on circle 1 exactly half way between the eight center points, A, B, C, D, etc., already found. In other words we must bisect the distance separating these points. We will pass from this for the moment and direct all our attention to what happened while drawing the eight circles 2, 3, 4, 5, 6, etc. It will be readily seen that these eight circles intersect or cross each other as at point E. Draw a light construction line (F) so that it will pass through

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* The shouldered end should be used for this purpose because it is not so likely to wear a hole in the paper.

EXERCISE IV

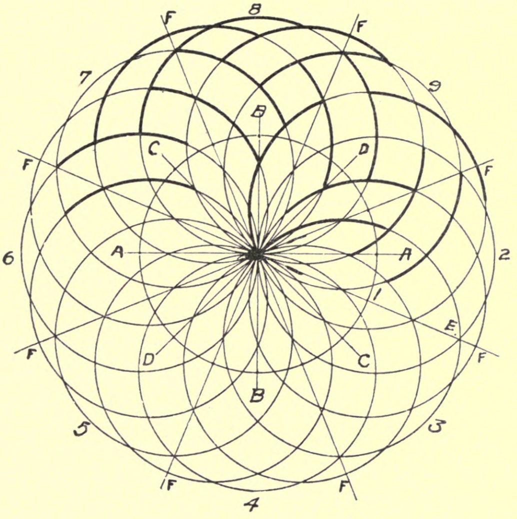


FIG. I

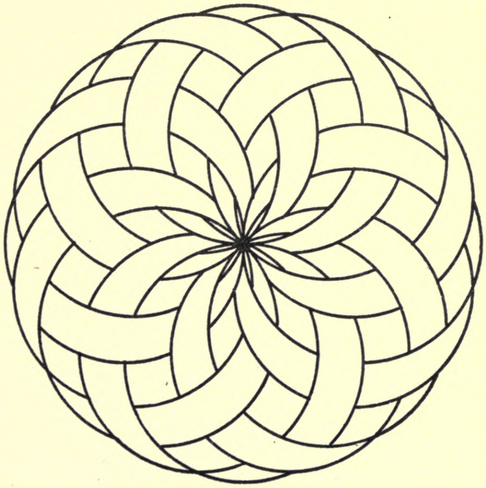


FIG. II

the center of circle 1, and also through the intersecting point E. Examine the work carefully and see if the distance A-C on circle 1 has not unknowingly and automatically been bisected by the line F just drawn.

In the same manner bisect the other distances, A-D, D-B, B-C, etc., and draw in the remaining eight circles, using the points just located on circle 1 as centers.

Brighten the required lines, erase all construction lines, and letter your plate properly. Exercise IV will then be completed. In Figure II, of Exercise IV, the completed design with construction lines erased is shown.

EXERCISE V—STRAIGHT LINES TANGENT TO ARCS OF CIRCLES

It is sometimes very difficult for the beginner to locate the exact center to be used in drawing a circle or semicircle. Especially is this the case when circles and semicircles are drawn in combination with and tangent to straight lines. The construction of preceding exercises, however, should prepare one to draw the different figures in Exercise V, all of which are used in problems to follow.

Figure I, Exercise V, shows the connection of two parallel lines by a combination of quarter circles. Draw vertical line A through the left extremity of line B. Extend line B to the left, and from the point C where lines A and B cross or intersect, measure off a distance (E) equal to the perpendicular distance between lines B and D. Draw vertical line F through point E, and horizontal line G parallel to, and in the center of the space separating parallel lines, B and D. It will be found that the exact centers of the circles to be drawn are the intersecting points of lines A and G, and F and G.

In Figure II is shown the proper method of locating the center of a circle to be used in rounding either the inside or outside of a corner.

With the Compass points set at the required radius, place the steel point in the corner marked A, and draw an arc or portion of a circle crossing lines B and C at points D and E. With points D and E as centers draw arcs or circles G and F. The point where arcs F and G cross or intersect will be the exact center from which to draw the required circle H.

Figure III is a combination of horizontal lines and semicircles. The location of all centers can be easily determined with but very little construction. A figure similar to this should now be possible of construction without further explanation.

EXERCISE V

FIG. I

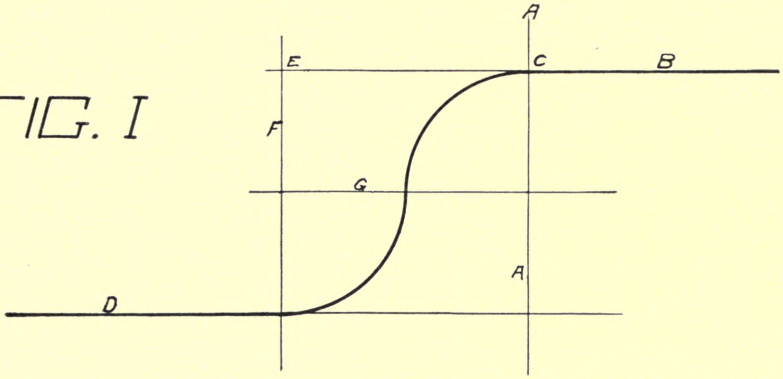


FIG. II

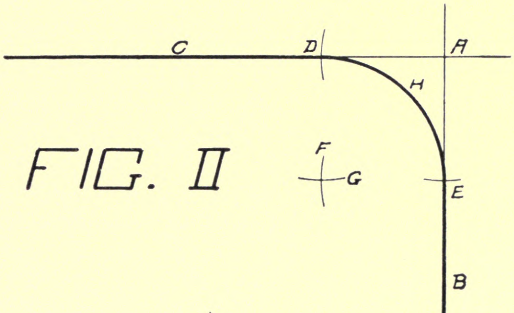
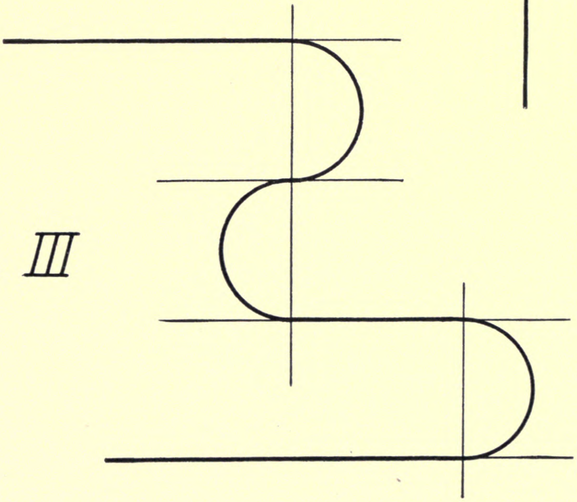


FIG. III



EXERCISE VI—ARC TANGENTS

This exercise can be constructed completely with the use of but one construction line—a light vertical line passing through the center of all circles and semicircles. Draw in the border line the same as in Exercise IV. On the vertical center line of the sheet and toward the bottom draw a faint vertical line five or six inches in length. Set the Bow Dividers to exactly 3/8″ and test for accuracy as explained in Exercise II. Step off on the vertical line thirteen points, commencing at the bottom.

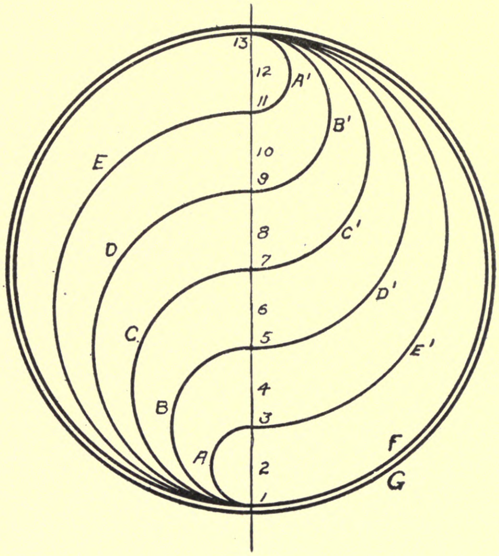
With the Bow Compass in proper condition (as explained in Ex. IV, p. 36.) place the steel point on 2 of Exercise VI, and adjust the Compass so that the lead will exactly touch points 1 and 3. Draw semicircle A, and without readjusting, place steel point of the Compass on point 12, and draw semicircle A′.

Place steel point of Compass on point 3, adjust the Compass so that the lead will exactly touch point 5 and draw semicircle B. Without readjusting the Compass, place the steel point on point 11 and draw semicircle B′.

Repeat this process, using points 4 and 10 for drawing semicircles C and C′, points 5 and 9 for drawing D and D′, points 6 and 8 for drawing E and E′, and point 7 for drawing circles F and G.

After you have lettered the plate properly and erased the construction lines, Exercise VI will be completed.

EXERCISE VI



PROJECTION DRAWING

PROJECTION I—CUBE

NOTE.—The problem of drawing three mechanical views of a cube with but one measurement taken is given not only as a quick way of locating points, but also to impress on the mind of the student the fact that the top view must always be in line with the front view and directly above it, and that a side view must always be in line with the front view and directly to the side of it.

A level surface such as the top of the Drawing Board or the surface of the drawing paper when tacked to the Drawing Board is commonly called a plane.

The Projection Drawing of an object is a combination of views representing the same object from different points of view. These representation drawings are commonly called Views, as front view, side view, and top view, and all are drawn on the one horizontal plane—the sheet of drawing paper.

The first problem in projections will be the drawing of the different views of a cube—an object which has six equal sides, faces, or surfaces.

If for some purpose a cube of wood or metal was needed, and a drawing of this cube was to be made, two views showing either the front and side, or the front and top, would be sufficient, as these views would give the length, width, and thickness. The drawing of a third view would not be necessary, but as a principle of Mechanical Drawing is involved that is very important to the beginner, the three views, front, side, and top will be required in this drawing.

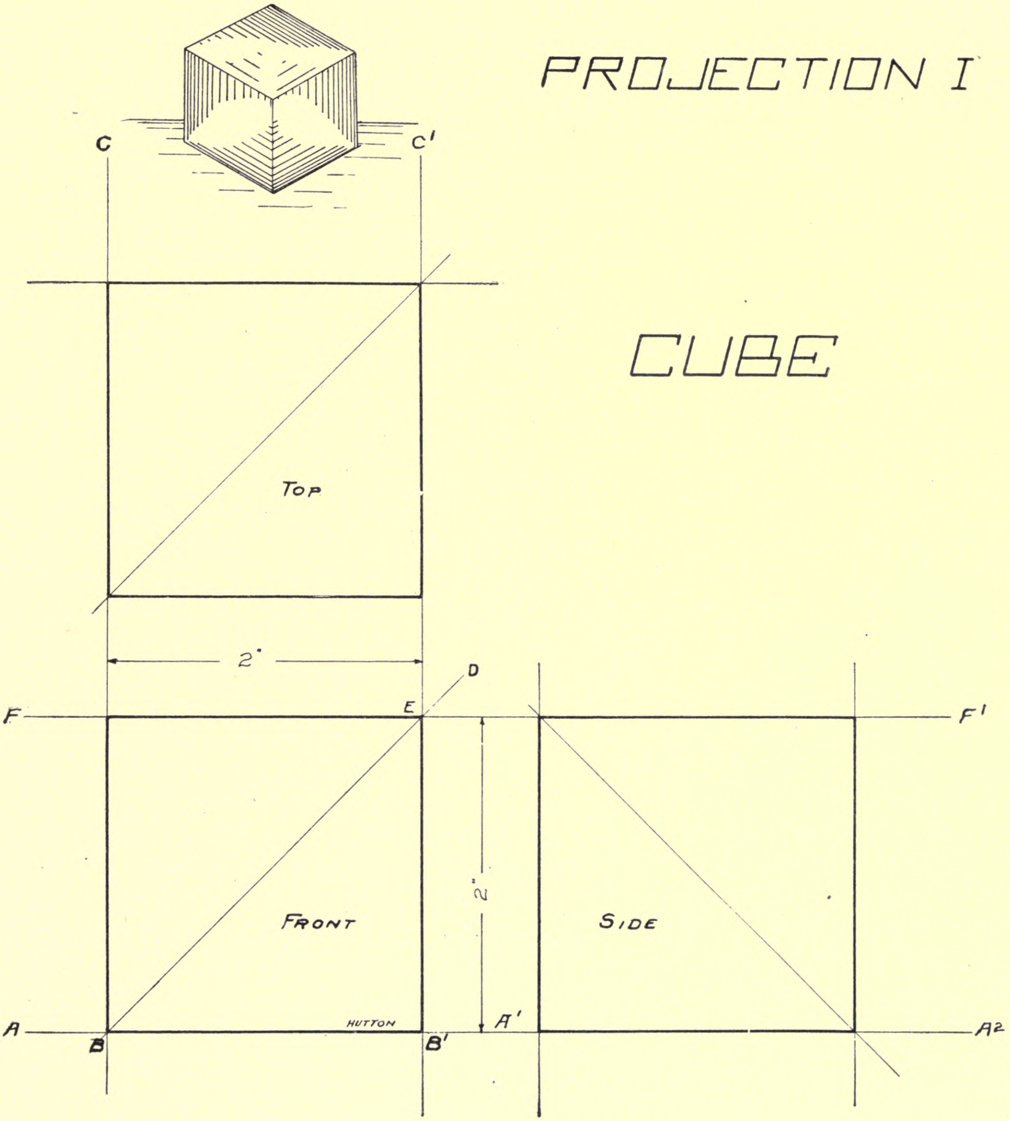
To represent a front view of a 2″ cube, draw a square measuring 2″ on each side. Draw the side view of the cube directly to one side and in line with the front view. This also will be found to be a square, each side of which measures 2″.

To represent a top view of a cube, proceed as in drawing the side or front view; that is, draw a square directly in line with the front view, and, in this case, above it.

After constructing the border lines the same as in the exercises, estimate at about what position you wish the drawing of the cube to

PROJECTION I

CUBE



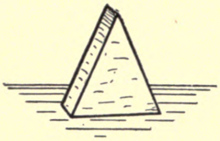
appear on the paper. When you have decided on this point draw the construction line A, A^1, A^2, representing the base line of the front view. Do not be afraid of making this line too long but be very careful not to make it too heavy. On this base line measure off with your ruler a distance of 2″ and mark it with a sharp pencil or needle. Make points B, B^1 as faint as possible, as they must not be seen when the drawing is completed.

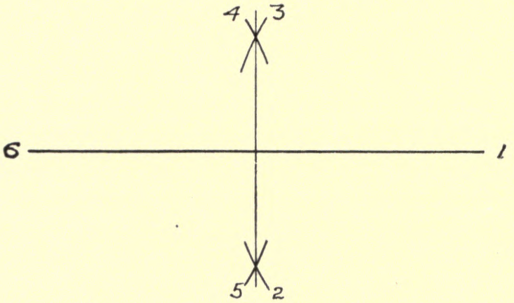
From points B, B^1 erect perpendicular construction lines B C and B^{1}C^1 indefinite in length. With the 45-degree Triangle draw diagonal construction line B D from point B so it will pass through vertical construction line B^{1}C^1 at point E. The distance from point B^1 to where diagonal B D passes through vertical line B^{1}C^1 at point E will be found to be exactly 2″ if the work has been done accurately.

The length and height of the front view have now been determined. Pass a horizontal line, F F^1, through point E. This completes the square. Study thoroughly the process of constructing a square by the aid of the T-Square and Triangle and with but *one measurement.*

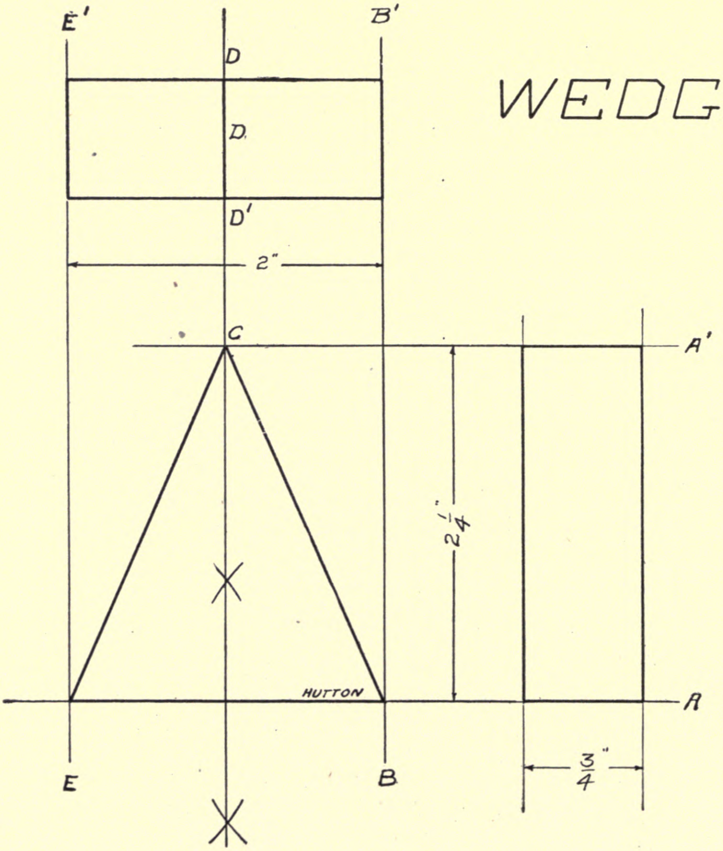
As the side and top views of a cube are both represented by a square, the faint construction lines projecting beyond the front view both at the side and top may be used to form a pair of sides for both the top and front views. Leave a neat space between views for the dimension lines and construct the squares representing the side and top views in the same manner as the front view was constructed. With the aid of the foregoing explanation and the construction lines shown in the side and the top views, this should be easily accomplished. When the three views are completed put in the dimension lines and dimensions as shown. Brighten or go over the squares representing the front, side, and top views. When these lines are inked they should correspond in thickness to those of the object line in Figure VI, page 23. Letter the plate and put in name, age, grade, school, etc., at the bottom. After all dirt, finger marks, and construction lines are erased, the plate, Projection I, is completed.

PROJECTION II





WEDGE



PROJECTION II—WEDGE

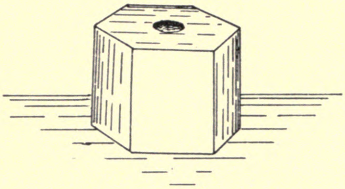
To make a projection drawing of a Wedge in three views will require three measurements only. In the projection of an object it is advisable, whenever possible, to draw the front view first. Extend the base and top lines as shown at A and A^1, thus locating the height of the side view. Extend lines B B^1 and E E^1, thus locating the length of the top view. The width of the Wedge shown in the top view will, of course, be the same as the width in the side view. Locating the vertex of the Wedge so that it will be in the exact center of the front view can easily be done without the use of the ruler by applying one of the first principles of geometry, that of bisecting a straight line (dividing a line into two equal parts). At the top of the plate, Projection II, is a line properly and geometrically bisected. Place the point of the Compass at one end of the line as at 1. Spread Compass so that its distance will be greater than half the length of the line, and draw arcs 2 and 3. Without changing the adjustment of the Compass repeat the operation by drawing arcs 4 and 5. In this operation use the other end of the line or point 6 as a center. Draw a line as shown connecting the points of intersection of the arcs. This line will be found to pass through the exact center of the line to be bisected.

Bisect in this manner the base line of the front view of the Wedge thus locating the center of the base. Draw a vertical line through this center and extend it far enough to locate the vertex of the Wedge, C, and also the line, D D^1, representing the edge of the Wedge as seen in the top view. The geometrical solution at the top can be omitted in the finished drawing if desired. It is assumed that by this time the student understands what lettering each individual drawing requires, and also which lines are to be brightened and which are not. With this drawing that part of the explanation will be discontinued.

PROJECTION III—HEXAGONAL PRISM

Projection III is the representation of a Hexagonal Prism 2″ in height, with a hole ½″ in diameter passing through it lengthwise.

In discussing Projection II it was said to be advisable, whenever possible, to draw the front view first, but in the construction of such drawings as the Hexagonal Prism, the top view should be drawn first, to locate at once the long and short diameters or to determine the exact width of



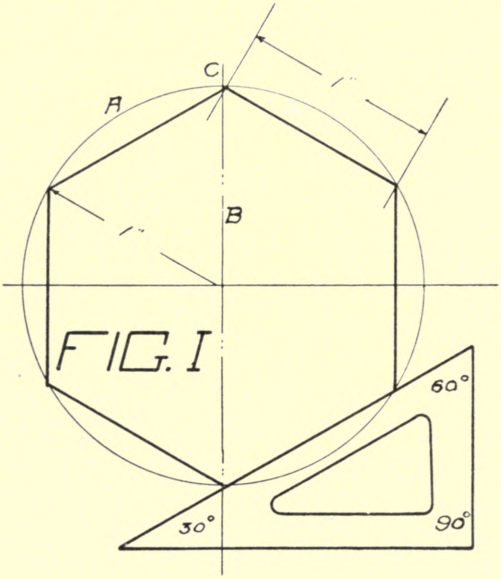
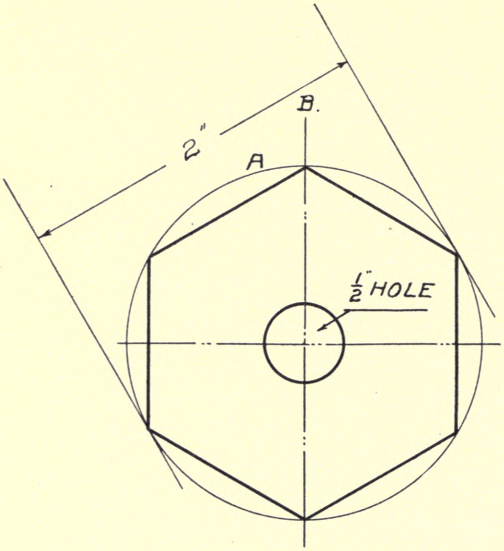
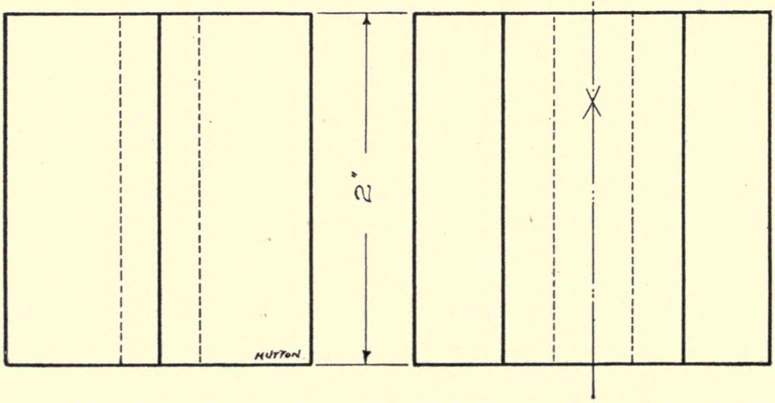


FIG. I

PROJECTION III





the front and side views. The drawing of the top view applies the geometrical principle of inscribing a regular hexagon in a given circle. (Fig. I). The diameter of the given circle equals the long diameter of the hexagon, which in this case is two inches. In Figure I in the upper right hand corner of the plate are shown two methods of procedure. In both methods it is necessary first to construct the circle of a given diameter, A, and through the exact center of this circle to erect a vertical center line, B. By the dimensions shown in Figure I it will be seen that the radius of the circle and the length of one side of the hexagon are equal. As the sides of a hexagon are all of an equal length it is plain that by the aid of the Compass or Divider, set to an exact distance of one inch, or the radius of the circle, the six equal sides can be easily located by spacing them off on the circumference of the circle, A. The starting point in this case should be at point C or the point where the vertical center line B intersects circle A. The other commonly used method of constructing a perfect hexagon is by the use of the T-Square and the 30-degree Triangle as shown in Figure I. This method should be understood without further explanation, as it involves only the proper use of the T-Square and Triangle.

The drawing shows, as has been previously stated, that a hole ½″ in diameter is to extend through this prism lengthwise.

The top view shows clearly the location of the half-inch hole. In the side and front views the hole would of course be shown by hidden lines; these lines would be ½″ apart, each ¼″ from the center line of the view.

If this hole were to extend only part way through the prism this information would be transmitted without verbal explanation by extending the vertical dotted lines to the required depth only, and by giving a dimension for this depth. The bottom of the hole would be shown by a dotted line drawn from the bottom of one vertical line to the bottom of the other or from one vertical dotted line to the other at the proper depth, thus showing the termination or the bottom of the ½″ hole.

It will be noticed that in representing the front view of the hexagon placed in this position three vertical object lines are necessary, while in representing the side view four are required. The reason for this should be thoroughly understood by the student. It will also be noticed that in order to locate the center line in the side view the geometrical principle of bisecting a straight line is again used.

If the problem in Projection III involved the making of a polygon with more than six sides, a different method of construction would necessarily be used. In Figure IV, p. 53, a convenient and easy method of dividing a circle into any number of equal parts is given.

After drawing a circle of the proper diameter, draw through its center a horizontal and a vertical center line as shown at A B and C D. Then divide the horizontal center line A B into as many equal parts as it is required to divide the circle—in this case seven. Divide the upper half of the vertical center line into four equal spaces as 1, 2, 3, and 4, and extend it upwards to point E beyond the circle, a distance equal to the length of three of these parts. Through point E and the second division point from the left of the center on the horizontal line A B, draw a line intersecting the circle at point G. It will be found then, if the work has been accurately done, that the distance represented by the heavy line A G is the required length of each of the seven sides. Set the Dividers to this distance and step around the circle.

If the top view in Projection III were to assume the shape of an ellipse, an approximately correct ellipse (Fig. II) or a true ellipse (Fig. III) could be constructed as described below.

To construct an approximately correct ellipse draw first the horizontal center line A B (Fig. II) then the vertical center line, C D. On each of these center lines, from their intersecting point E measure off one-half of the corresponding long and short diameters of the ellipse. On the long diameter, from A, measure off a length equal to the short diameter, thus locating point F. Divide the remaining portion of the horizontal line into three equal parts as 1, 2, 3. With E as a center and the Compass set to a distance equal to the length of two of these parts, as 1 and 2, draw arcs cutting horizontal center line A B at points Y and Z. Set the Compass to the distance Y Z, and with Y as the center draw arcs P and Q; with the same radius, and with Z as a center draw arcs M and N. With the intersecting points of arcs M and P and N and Q and the points Y and Z as centers draw the ellipse as shown by the radial dimension lines.

In constructing a true ellipse it will be necessary to draw from the same center two circles, one with a diameter equal to the short and one with a diameter equal to the long diameter of the desired ellipse. Divide the larger circle into an equal number of parts (24 will be sufficient) by the aid of the 45-degree and 30-degree Triangles, used singly

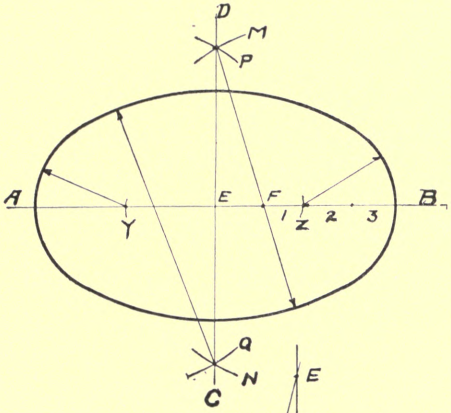


FIG. II

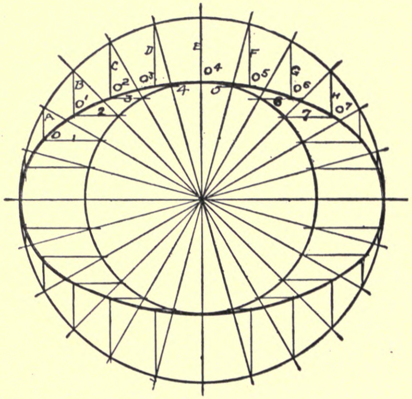


FIG. III

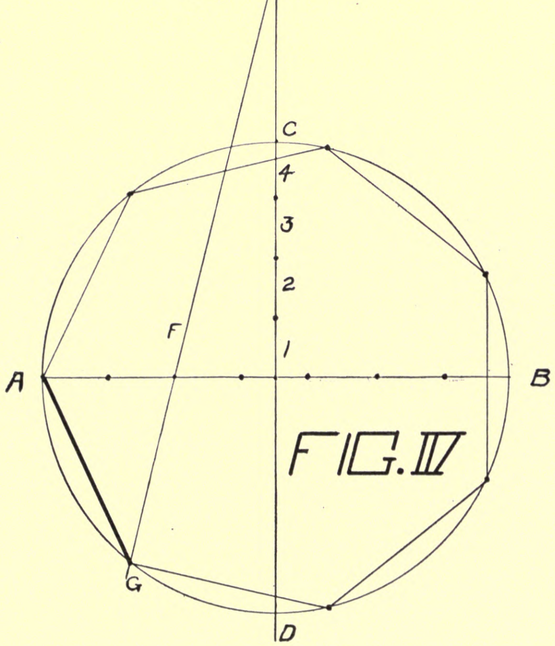


FIG. IV

FIG. 2 TO CONSTRUCT AN APPROXIMATE OVAL

FIG. 3 TO CONSTRUCT A TRUE OVAL.

FIG. 4 TO DIVIDE A CIRCLE INTO ANY NUMBER OF EQUAL PARTS.

HUTTON

and in combination. Connect these division points with the center of the circles as shown. From the division points of the large circle project vertical lines A, B, C, D, E, etc., and from the division points on the small circle, formed by the radii of the large circle, project horizontal lines 1, 2, 3, 4, etc. Through the intersection points of these corresponding vertical and horizontal lines, as 0, 0^1 0^2, etc., carefully draw by the aid of the Irregular Curve, the desired ellipse.

PROJECTION IV—CAST IRON RING

Projection IV is that of a cast iron cylindrical ring. Two methods of representation are shown, both of which are correct. If in drawing the front and side views of the ring, no principles other than those that have been previously given were to be used, the front view (Fig. I) and the side view (Fig. II) would be sufficient. But in the representation of objects it is often necessary to make what is termed a section drawing,—a drawing of a section or cut through the object, (Fig. III).

In drawing the section of an object a true representation must be shown of what the object would look like at the particular place where the object is cut in imagination. Imagine a cut made through an object, as with a saw, and then show an exact representation of that part of the object the saw passed through as looked at squarely toward the cut surface.

This method of representing an object, or some particular part of an object, is used principally to show more completely the shape, location, or construction of some part or parts not clearly shown in the ordinary way. Advantage is generally taken of a sectional drawing to make it show from what material the object is to be made, by crossing the section diagonally with a series of lines and combinations of lines, each combination representing a certain material. (See page 56.)

In Projection IV, Figure III, is shown a sectional drawing of the cylindrical ring, the line of intersection being A A (Fig. I). By comparing the section lines shown in Figure III with the small squares on page 56, properly sectioned as previously mentioned, it will be seen that cast iron is the material from which the ring is to be made.

In the execution of this problem the usefulness of an occasional sectional drawing is by no means fully covered. The problem is given only to acquaint the student with the principle involved.

PROJECTION IV

FIG. III

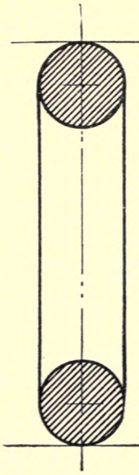


FIG. I

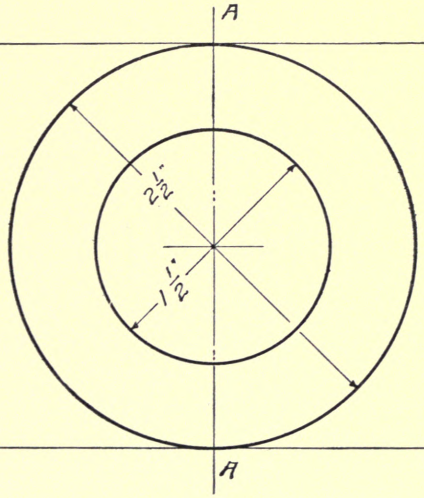
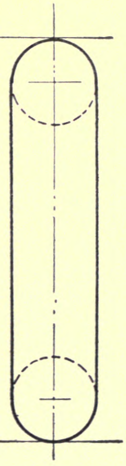


FIG. II



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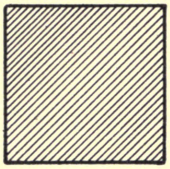
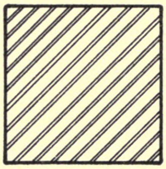
SECTION LINES

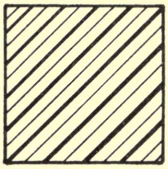
CAST IRON



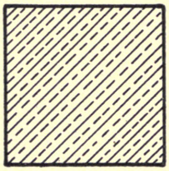
STEEL



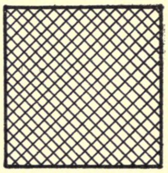
WROUGHT IRON



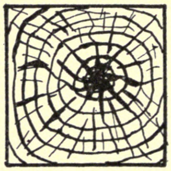
BRASS



BABBITT



WOOD



PROJECTION V—PIPE CUT AT AN ANGLE

The projection drawing of a piece of pipe to show all required dimensions would necessitate but two views, the front view to show the length, and the top view to show the inside and outside diameters.

If, for any purpose, this pipe were to be cut at an angle, the angle also could be shown in the front view, but if for any reason it were required that the exact shape of the end cut at an angle be shown, this exact shape would have to be developed or drawn in a view parallel to the cut. The drawing of a piece of pipe cut off at one end at an angle of 45 degrees is shown in Projection V. Four views are given so that all principles involved can be easily understood.

In reproducing this drawing the inside diameter should be 1½″, the outside diameter 2″, and the extreme length 3″.

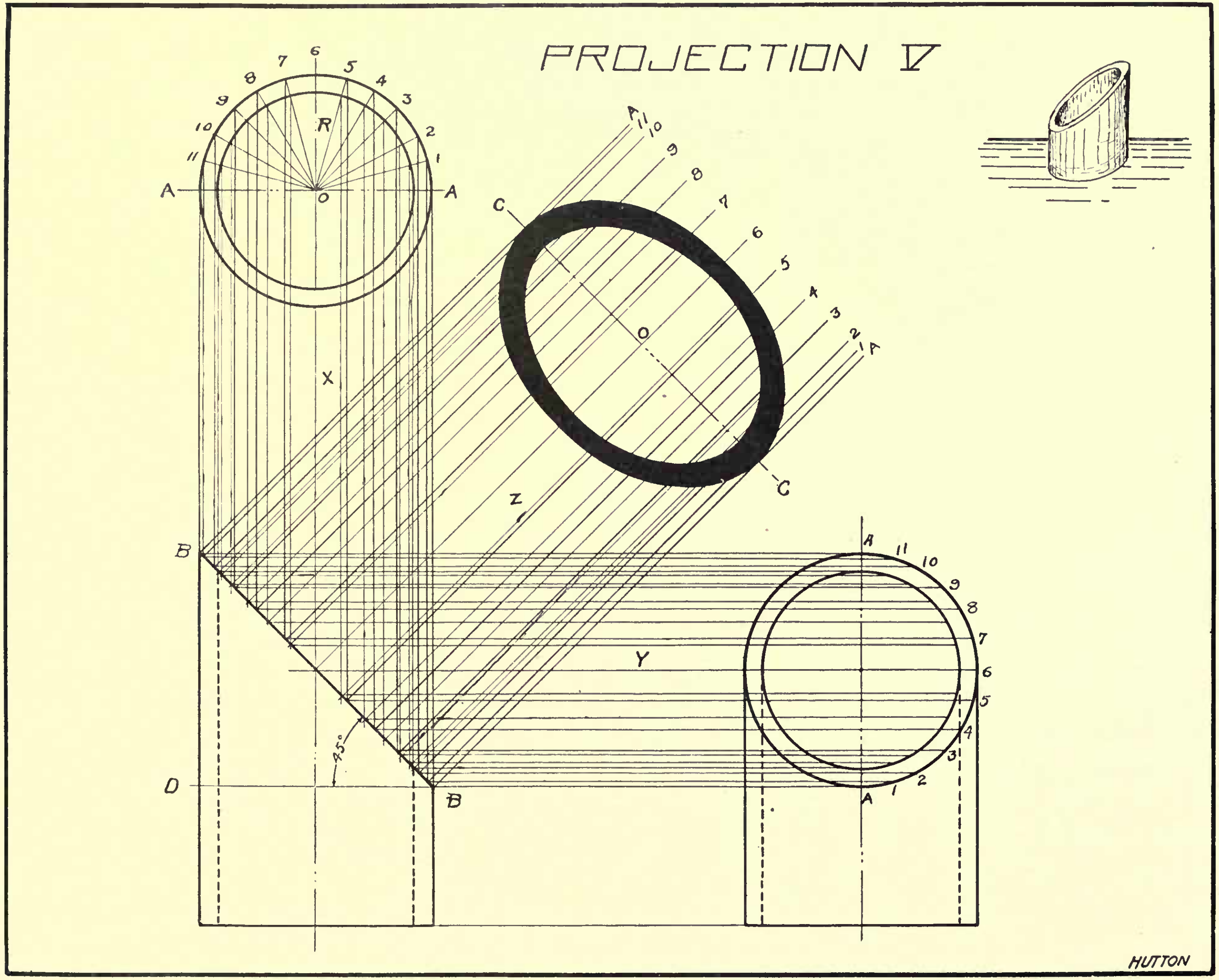
Draw the top and front views according to the above measurements, and show the top end of the pipe cut at an angle of 45 degrees. Divide the upper half of the circle representing the outside diameter into any number of equal parts (12 will be sufficient, as 1, 2, 3, 4, 5, 6, etc.). Draw the series of lines, R, connecting these points with the center of the circle O; then with the series of lines X project points 1, 2, 3, 4, etc., until they intersect or cross line B B, which represents the edge of the top of the pipe.

It has been previously stated that if an exact representation of the end of the pipe cut at an angle be desired, the view of the end would have to be made with its center line parallel to the cut B B.

Draw center line C C exactly parallel to B B as shown, and with the 45-degree Triangle and the T-Square draw projecting lines Z from the intersecting points of lines X and line B B through center line C C. This will locate on center line C C the true length of the slanting end of the pipe.

By referring to the perspective drawing of this pipe it will be seen that the end of a pipe cut at this or any other angle gives the appearance of an ellipse. The line representing an ellipse comes under the head of a line otherwise than straight, but which cannot be drawn with a compass. It must therefore be drawn by the aid of an Irregular Curve.

PROJECTION V



By referring to the description and use of the Irregular Curve (page 14) we see that a series of points directly in the path of the curve to be drawn must be located.

Before proceeding with the location of these points the student's attention is called to the fact that the space between the view of the outside and the inside of the pipe is blackened merely to add reality to the appearance. In the drawing executed by the student the outside and the inside of the ellipse must be represented with lines corresponding in thickness to an object line, and the space between the ovals must be left white.

It will be noticed that the points at the termination or ends of diagonal lines Z are marked to correspond with the division points on the upper half of the circle in the top view, 1, 2, 3, 4, etc., and also that these points can be directly traced through intersecting points on line B B. Adjust the Bow Dividers so that one point rests on O and the other point on 6 of the top view. With O on C C as a center, transfer this distance to each side of the center line C C. This locates the extreme width of the outside ellipse. To locate the second widest point adjust Dividers to the exact space between point 5 and line A A in the top view, and transfer this distance as before to each side of the center line C C on line 5, series Z.

It is evident that this distance is the same as that from point 7 to line A A in the top view. So, without readjusting Divider points, transfer the same distance each side of the center line C C on line 7. Continue this process until all points have been located. If the work has been accurately done a curve passing through all points will produce an ellipse.

The ellipse representing the inner part of the diagonal end of the pipe can be located in exactly the same manner. Since the inner circle in the top view is already divided into the required number of equal spaces by the intersection of lines R, you can proceed as before to draw lines X from these intersection points to line B B. Then from intersecting points of lines X and line B B draw lines Z through center line C C.

Transfer the distances from line A A to points on the inner circle in the top view, formed by the intersecting radii, over to their proper locations and on each side of center line C C. Construct the inner ellipse in the same manner as for the outside ellipse.

A careful study of this problem and the one following must be made by the student, as they involve a principle often met with in the proper representation of objects. Study also the reason for showing the diagonal end of the pipe in the side view as follows.

In the front view of a cube (Projection I) the height was located by drawing a line from the intersection of vertical line B C and base line $A^1 A^2$ through the other vertical line $B^1 C^1$ at an angle of 45 degrees. Since you know that this drawing is correct and that the length of the line representing the base as $B B^1$ is equal to the height, B^1 E, the natural consequence of cutting the pipe in Projection V at the same angle of 45 degrees can easily be imagined; that is, the vertical height of the cut equals the diameter of the pipe. This being the case, the height of the cut in the side view equals its width. As a consequence, a circle shows the side view of the cut end of the pipe.

To prove this in your own mind, draw horizontal lines Y from intersecting points on B B through the side view as shown, and check or try with the Divider the distances from A-A to 1, 2, 3, 4, etc., in both top and side views. In the operation determine whether or not they are of the same length.

Hold a book at arm's length from the body with the flat side of the book directly facing the eye and you will see that a view of the book in this position shows its exact dimensions. Hold the arm in the same position and turn the book gradually until none of the side can be seen. The edge will then directly face the eye. So it is in drawing the side view of the cut on the end of the pipe. Were the cut made at a 40-degree angle with the line B D instead of a 45-degree angle, the side view would show it wider than it is high. Were it made at a 50-degree angle with the line B D instead of a 45-degree angle, the side view would show the cut higher than wide.

This proves that the side view of an object whose front view does not show all parts of the object in a vertical position does not give the *true* dimensions of these parts.

PROJECTION VI—CONE CUT PARALLEL TO ITS AXIS

A cone is a body which has a circle for a base and which terminates in a point at the top. To make the projection drawing of a cone in three views would be a simple matter. To draw the front view one would draw a triangle with a given base and altitude, or height. As it is alike on all sides, the side view would be the same as the front view. To draw the top view one would draw a circle whose diameter would be equal to the diameter of the base of the cone, with a dot or point in the center of the circle representing the top.

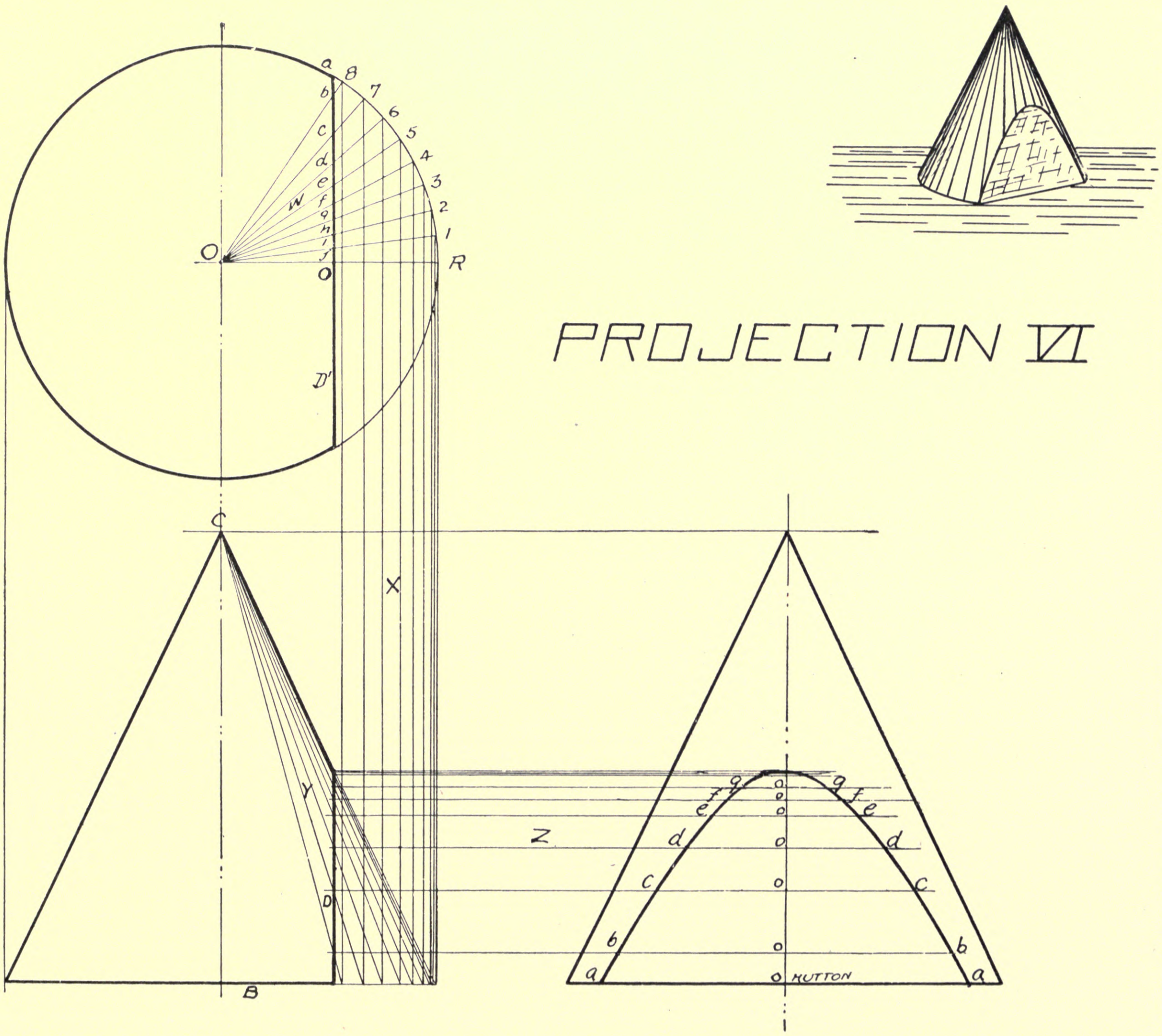
Occasionally during the process of representing an object on paper the outline of an irregular curve formed by the intersection of a plane with the object must be drawn. A good illustration of this is given in Projection VI. The small perspective drawing in the upper right hand corner of the plate shows a cone flattened on one side as if a portion had been cut off. The fact that the cone is round at the base and tapers to a point at the top would naturally cause the edge of this flattened surface to form a peculiar curve.

In Projection VI the cut is made in this instance at one side of and parallel to the center line or axis of the cone. Draw the front, top, and side views of the cone so that it will be 2¾″ wide at the base and 2¾″ high. Also draw the vertical lines D and D^1 on the front and top views representing the edge of the cut surface or the cutting or intersecting plane. The exact location of this line is not important.

Through the center of the circle representing the top view draw the horizontal line O R, and from the point where line O R touches the circle step off on the circle seven or eight points, as 1, 2, 3, 4, etc., with the Bow Dividers. From these points draw lines W, connecting them with the center of the circle. From the points 1, 2, 3, 4, etc., just located on the circle, project lines downward until they touch line B or the base line of the cone originally shown. From the points where these lines, (X), intersect the base line B draw diagonal lines Y, connecting these points with the vertex or top of the cone at C. Note that the lines Y cross diagonally line D. Through the points located by the diagonal lines Y crossing line D draw horizontal lines Z through the side view of the cone.

The length of line D^1 in the top view is the same as the width of the cut side at the base of the cone as shown in the side view at a-a. The

PROJECTION VI



height of line D in the front view is the same as the height of the cut side of the cone, also shown in side view on its center line. There are of course as many lines (Z) between the base and the top of the cut side in the side view as there are points located on the circle above R, as 1, 2, 3, 4, etc., in the top view, because each of these lines (Z) can be directly traced back through intersecting points on the front view to points 1, 2, 3, 4, etc., of the top view.

Therefore the points 1, 2, 3, 4, etc., in the top view bear a direct relation to the spacing of lines Z in the side view. It is to be noted also that the distances from the intersecting points of lines W and line D^1 to the intersecting point o of lines O, R and D^1 are the same as the distances spaced off on lines Z each side of the center line in the side view.

Using point o in the top view as the center, set the Dividers to o a and transfer this distance to o a on the base line of the side view on each side of its center line. The line a a in this view thus gives the width of the cut surface on the base of the cone. Transfer distances o b, o c, o d, etc., from the top view, to o b, o c, o d, etc., on each side of the center line in the side view as before, thus locating the points through which the natural path of the curve must pass.

Through these points, with the aid of the Irregular Curve as illustrated in Figure III, page 15, carefully pass the required curve.

WOOD-WORKING DRAWINGS

Note. It is not intended that the wood-working problems given should be strictly followed in the shop unless it is so desired. It is necessary, however, that the student should draw and thoroughly understand all problems given, even though not all of them are described, as they were designed by the author for the purpose of covering, one step at a time, the practical methods of clearly and concisely representing objects constructed of wood. Number the drawings 1, 2, 3, 4, etc. In cases where the details are shown on separate sheets, give the detail sheets the same number and also a sheet letter, as drawing number 5 for the assembly, and drawing number 5, sheet A, B, C, etc., for the details. The assembly and detail sheets of each object should be fastened together with a separate sheet which acts as a cover or protector. This cover sheet may be lettered as follows, for example: ''Detail and Assembly Drawing of a Pedestal. Drawing number 9. Drawn by Bennie Drayer, Age 14, Grade 8A; Date, January 9th, 1915, Indianola School, Columbus, Ohio.''

By keeping the drawings in their proper order in the portfolio as previously described, any set of drawings may be located at once, and the work of any student can be seen by teacher, principal, or visitor at a moment's notice.

DRAWING BOARD

The Drawing Board shown on the opposite page is of ample dimensions to accommodate a paper sufficiently large for the execution of all drawings herein given.

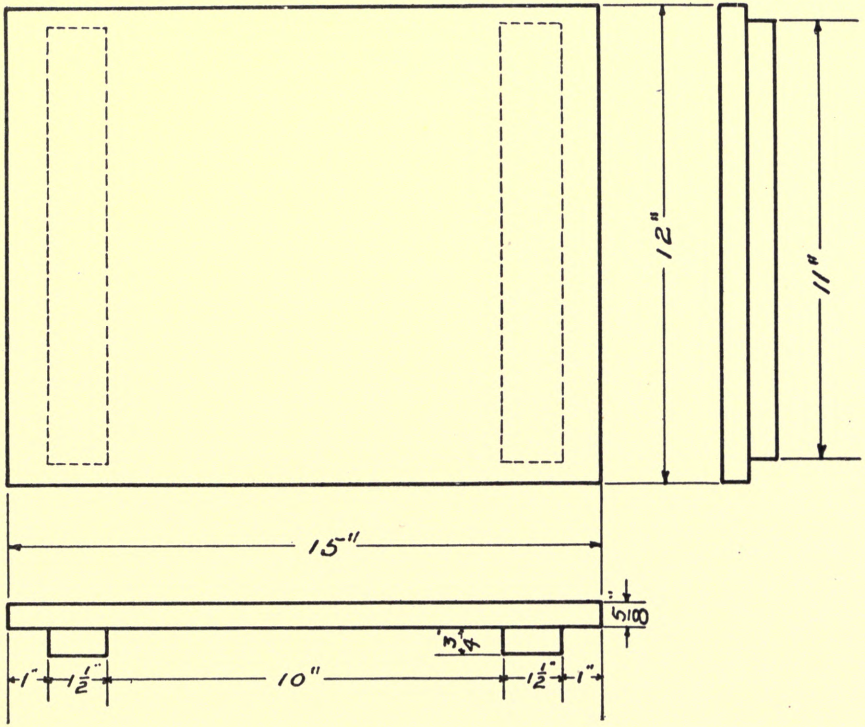
This Drawing Board is composed of three pieces of material: a top which is 5/8″ thick, 12″ wide, and 15″ long, and two cleats, or reinforcing strips, which are 3/4″ thick, 1 1/2″ wide, and 11″ long. The purpose of these reinforcing strips is to prevent the top from warping. They are to be fastened to the under part of the top, in the position shown, by means of flat-headed screws.

The drawing of the Drawing Board should be made with as few measurements as possible. This is not difficult, as the only principle involved is the proper use of the T-Square and the Triangle. For example, make a 12″ measurement in one place only. Then with the T-Square held in proper position draw a horizontal line through each of the points located by this 12″ measurement, using the top edge of the T-Square blade as a guide for the pencil. These lines will locate the width of the board along its entire length and will also locate the width of the board as shown in the end view. The same principle applies in locating the length of the board at all points on the top and front views with this exception: one 90-degree edge of a Triangle is used as a guide for the pencil, while the other 90-degree edge rests on the top edge of the T-Square blade.

Note:—Review the problem of drawing a cube, Projection I, page 45.

DRAWING BOARD

SCALE 3" = 12"



PIN TRAY

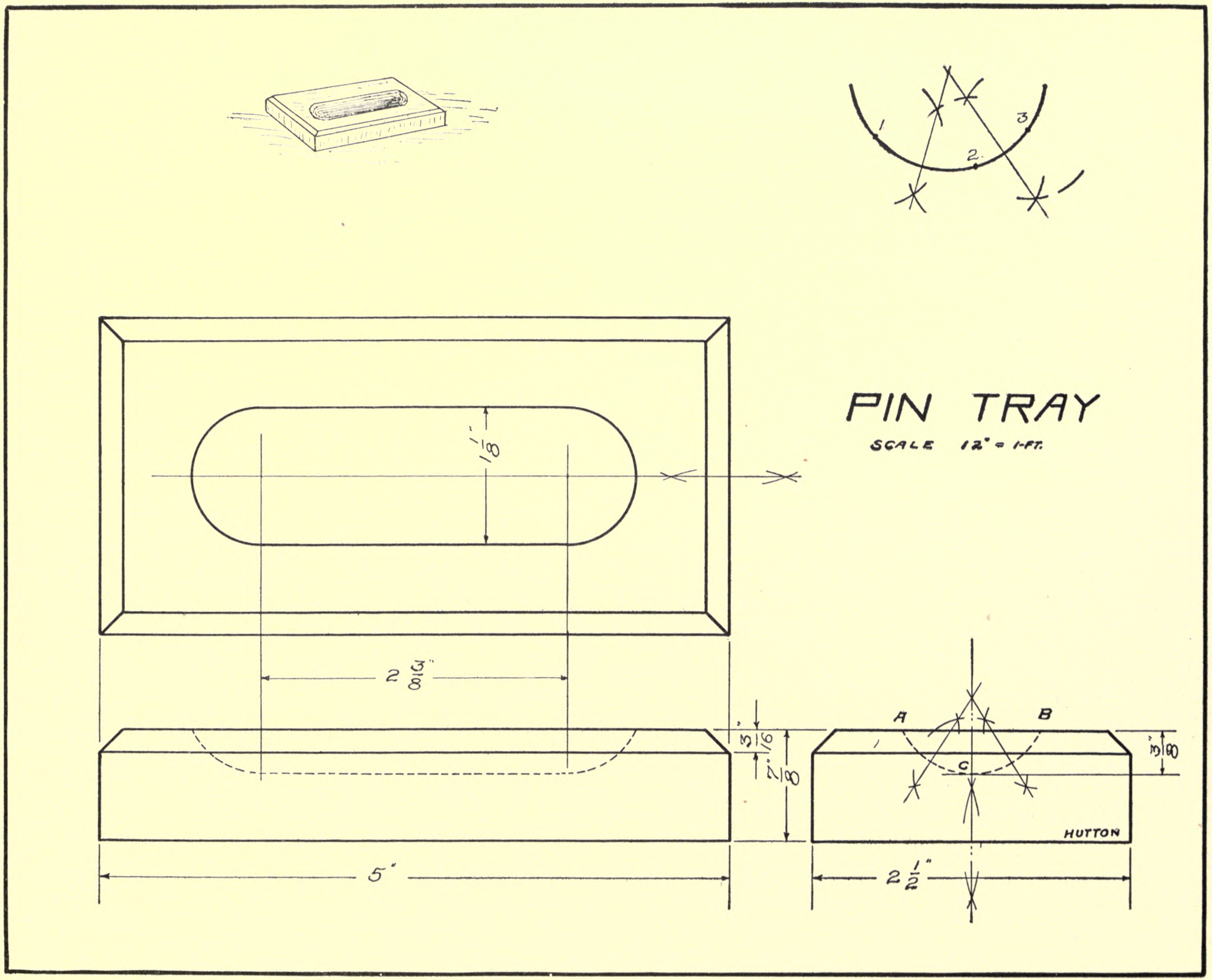
The general outline of the Pin Tray shown is that of a rectangular prism or a plain block of wood $\frac{7}{8}''$ thick, $2\frac{1}{2}''$ wide, and $5''$ long.

At a glance it can be seen that the block thus described is to have the top edges chamfered to a required dimension. This is shown plainly in any one of the three views. The fact that a dimension for this chamfer is given at only one point on the drawing indicates that the size of the chamfer continues to be the same at all points on the edge of the tray. The outline of the groove as shown in the top view with its given dimension denotes its width and shows that it is semicircular in shape at both ends. With the radius of the circles omitted and the distance between centers given, as in this case, it is understood that the diameters of the circles to be drawn equal the distance separating the lines they are to connect, or $1\frac{1}{8}''$. As the radius of a circle always equals the half of its diameter, the full length of the groove is plainly but indirectly shown.

The groove is shown in the side or front view to extend the same depth for a distance of $2\frac{3}{8}''$, or the distance between the centers of the end circles. If it were not to extend the same depth, a dimension for its depth at various points between these centers would be given. The end view shows by dotted lines the end shape of the bottom of the groove, which is also circular. The proper placing of this dotted line appears at first an easy matter, but it will require considerable thought on the part of the student. Considering that in the top view there is no dimension given for the exact location of the groove, it will be understood that it is to appear in the exact horizontal and vertical center of the tray. The ends of the dotted lines representing the bottom of the groove in the end view must show the width of the groove at the top or widest point, and must appear at the exact required distance each side of the vertical center of this view. As the bottom of the groove is circular in shape, as previously explained, a point must be located from which the circle can be drawn to allow it to pass through a point on the end view center line representing the exact depth of the groove. There are, therefore, three given points through which this circle must pass: A and B representing the top edges, and C the bottom center of the groove.

In the upper right hand corner of the plate is given the geometrical principle involved in locating a point, from which, when used as a center, a circle can be passed through any three points not in a straight line. Let 1, 2, 3 be the points through which the required circle is to pass.

Bisect the distance between the points 1 and 2, allowing the bisecting line to extend upward. Bisect the distance between the points 2 and 3



PIN TRAY

SCALE 12" = 1-FT.

and extend the bisecting line upward until it crosses the bisecting line of points 1 and 2. The intersecting point of these bisecting lines will be found to be the desired point from which a circle may be drawn that will pass through the given points 1, 2, 3.

Apply the same principle in passing a circle through the given points A, B, and C in the end view and study until thoroughly understood. Dimension the drawing as shown. Erase all construction lines and the plate entitled ''Pin Tray'' is completed.

CLOTHES LINE REEL

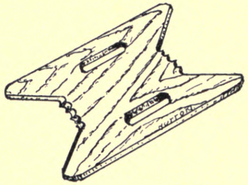
Before attempting to draw the Clothes Line Reel, review thoroughly the description and use of the Scale Rule as given on page 16, and at the same time space off on a series of lines a distance representing:

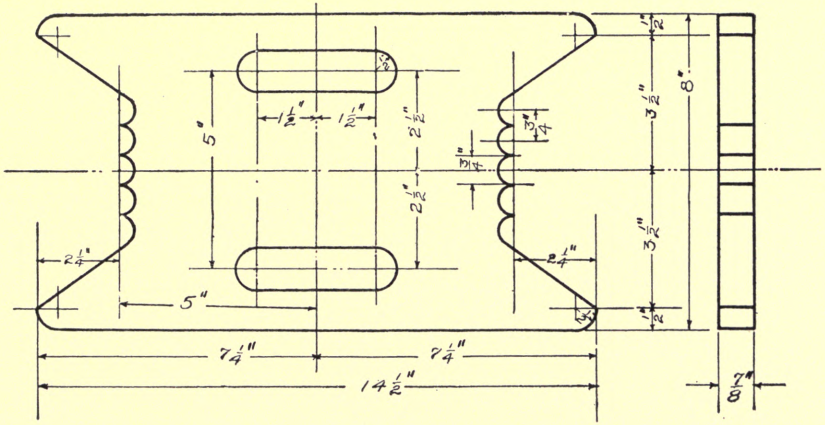
2′ 0″	at the scale of	3″	equals 1 foot.
1′ 6″	“ “ “ “	3″	“ “ “
8′ 0″	“ “ “ “	3″	“ “ “
14½″	“ “ “ “	3″	“ “ “
2′ 6″	“ “ “ “	1½″	“ “ “
1′ 9″	“ “ “ “	1½″	“ “ “
2′ 4″	“ “ “ “	1″	“ “ “
1′ 8″	“ “ “ “	1″	“ “ “
3′ 9″	“ “ “ “	¾″	“ “ “
2′ 7½″	“ “ “ “	¾″	“ “ “
5′ 6″	“ “ “ “	½″	“ “ “
2′ 3″	“ “ “ “	½″	“ “ “
12′ 6″	“ “ “ “	⅜″	“ “ “
4′ 9″	“ “ “ “	⅜″	“ “ “
20′ 0″	“ “ “ “	¼″	“ “ “
18′ 6″	“ “ “ “	¼″	“ “ “
32′ 6″	“ “ “ “	3/16″	“ “ “
11′ 6″	“ “ “ “	3/16″	“ “ “
20′ 6″	“ “ “ “	⅛″	“ “ “
15′ 9″	“ “ “ “	⅛″	“ “ “
40′ 0″	“ “ “ “	3/32″	“ “ “
37′ 6″	“ “ “ “	3/32″	“ “ “

By measuring accurately from center lines in both horizontal and vertical directions, and by working carefully, the student should be able to draw straight and curved lines in combination and produce this plate properly without further explanation.

CLOTHES LINE REEL

SCALE 3"=12"





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CLOTHES LIFTER

The Clothes Lifter shown is constructed of three pieces, namely: bar, handle, and spreader. It will therefore be necessary to make, aside from the assembly, a detailed drawing showing each piece in as many views as is necessary to locate all dimensions.

The sectional square drawn in the center of the assembly shows the size and shape of the bar between rivets.

In the detail of the bar both ends are shown to be tapered on two sides from the rivets out.

In the front view of the handle are shown dimensions for making the saw cuts, while in the end view the handle is shown to be round.

In the front view of the spreader the shape is shown to be that of a wedge, with sides concave to the extent of ¼″. The end view of the spreader shows both width and thickness.

Where objects are constructed of several parts, as is the case in the Clothes Lifter, a material list must be compiled. In compiling a material list allowance must always be made for material to be wasted in the process of finishing or bringing the piece to its actual shape and size. The detail of the bar shows it to be, when finished, 1¼″ × 1¼″ × 3′ 1″. In order to make proper allowances, the material list for the bar must read: 1 piece, 1½″ × 1½″ × 3′ 2″, etc.

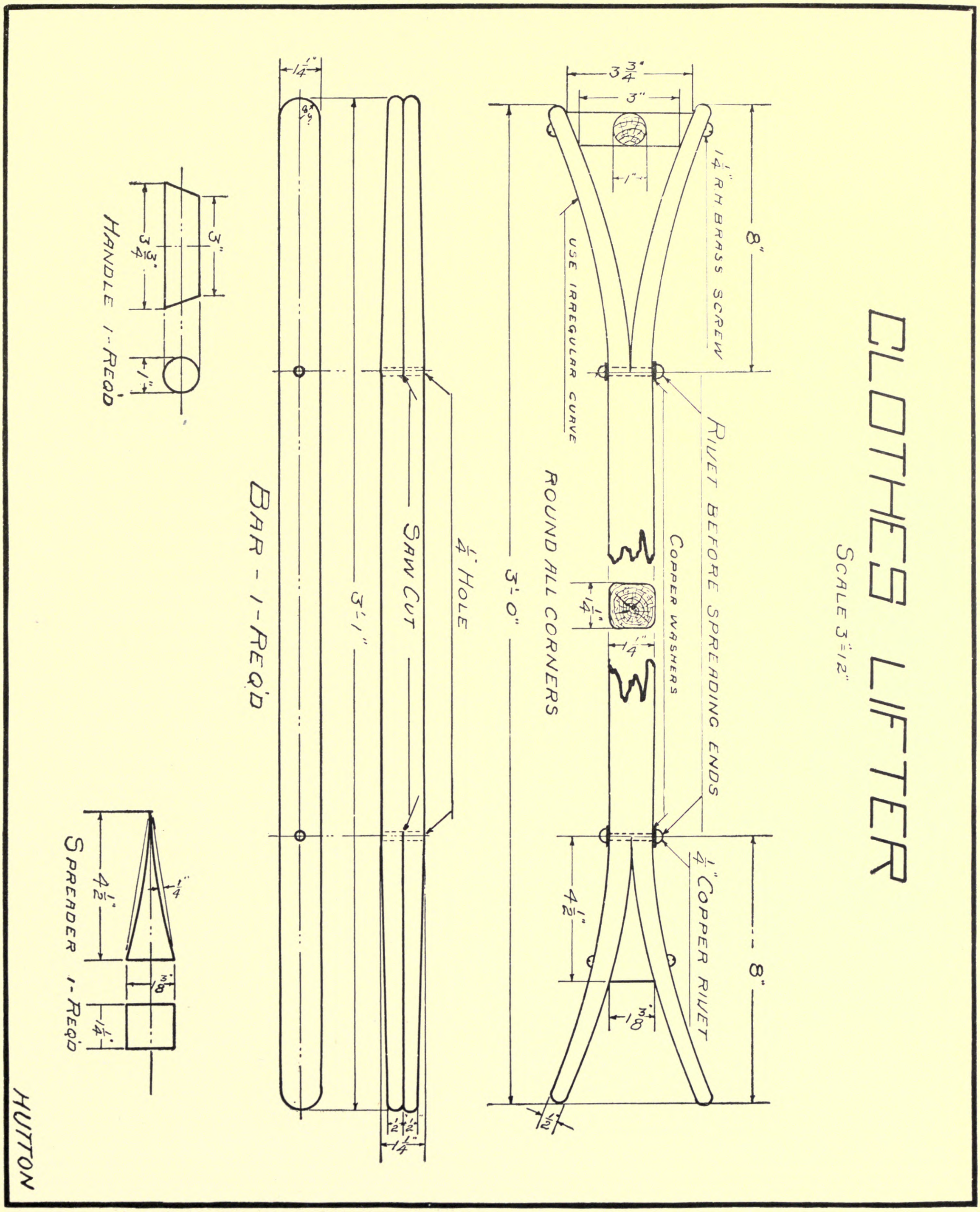
In the following problems the student, after the assembly and details have been drawn, should be able to furnish accurate material lists without further help or explanation.

In compiling any material list composed of numerous parts and materials, the most concise method is to make a tabulation as shown below.

MATERIAL LIST

Library Table

No. Pieces Reqd.	Name	Size	Material
1	Top	⅞″ × 30″ × 46″	Oak
4	Posts	3″ × 3″ × 29″	Oak
		Etc.	


CLOTHES LIFTER
SCALE 3"=12"
3 3/4"
3"
1"
1/4" RH BRASS SCREW
8"
USE IRREGULAR CURVE
RIVET BEFORE SPREADING ENDS
ROUND ALL CORNERS
3'-0"
COPPER WASHERS
1 1/4"
1 1/4"
1/4" COPPER RIVET
4 1/2"
8"
1 3/8"
1/2"
1 1/4"
SAW CUT
1/4" HOLE
3'-1"
1/2"
1/2"
1 1/4"
BAR - 1 - REQ'D
3"
3 13/16"
1"
HANDLE 1-REQD
4 1/2"
1/4"
1 3/8"
1 1/4"
SPREADER 1-REQ'D
HUTTON

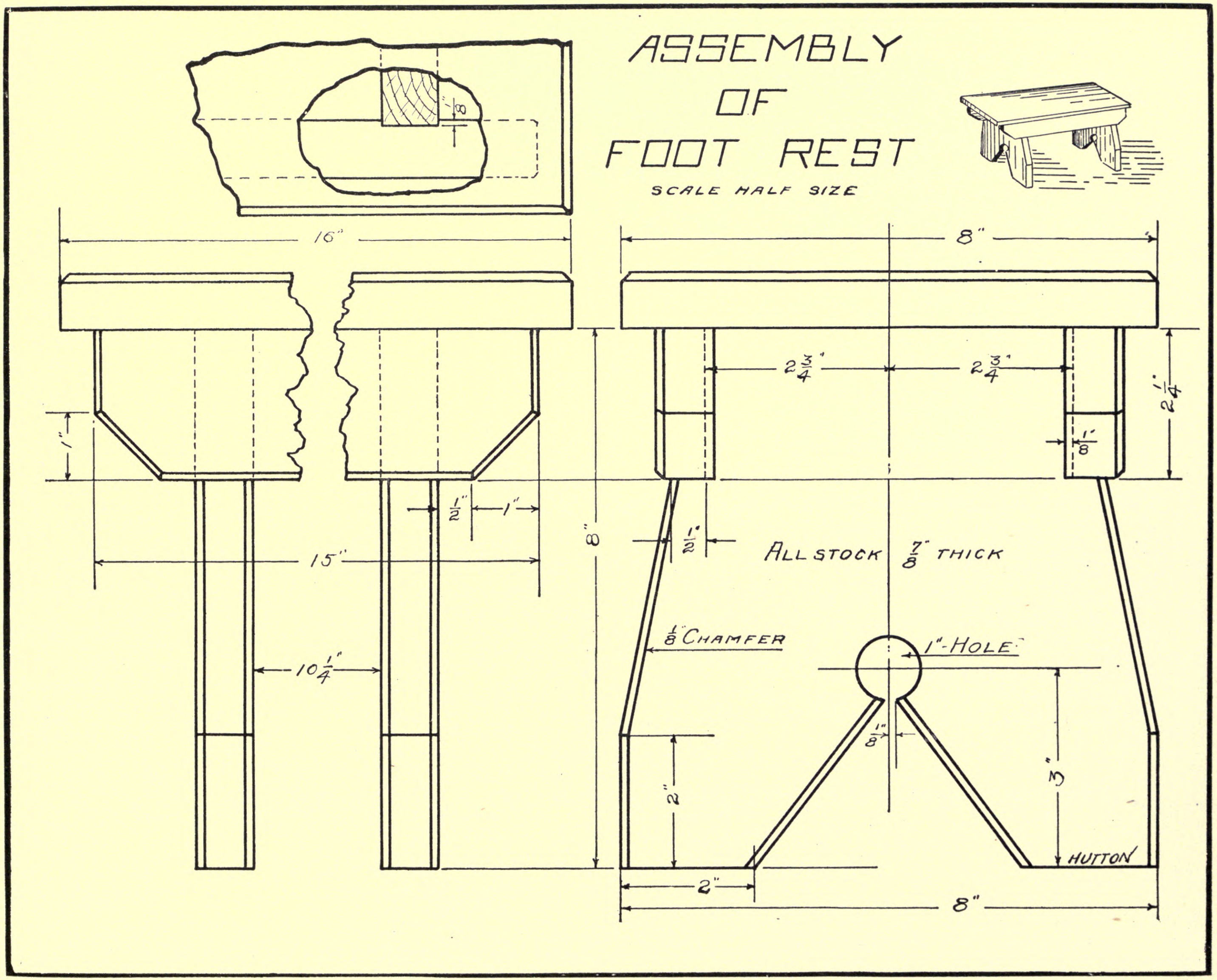
FOOT REST

The drawing of the Foot Rest presents a principle which can very often be applied, especially when it is desired to draw to as large a scale as possible within a limited space.

It will be noticed in the front view that the length of the top is to be 16″. This, drawn to a scale of 6″ to the foot, or half size, would be 8″, while the length of the drawing is considerably less. Since there is not room on the paper for a full half-size view, and since the size and shape of all parts of the stool between the legs are the same, it is customary and proper to show this view with a piece broken out; thus the legs and ends are brought closer together than the scale demands. The over-all dimensions, however, must be fully indicated, and the legs and ends of the sides and top must be drawn true to scale.

In the top view it is not necessary to show the entire top as the corners are all constructed alike. In certain cases it is customary and proper, in order to show clearly some particular part or construction of an article, apparently to break out a section of the surface, thus allowing the construction to be shown clearly and with a full line.

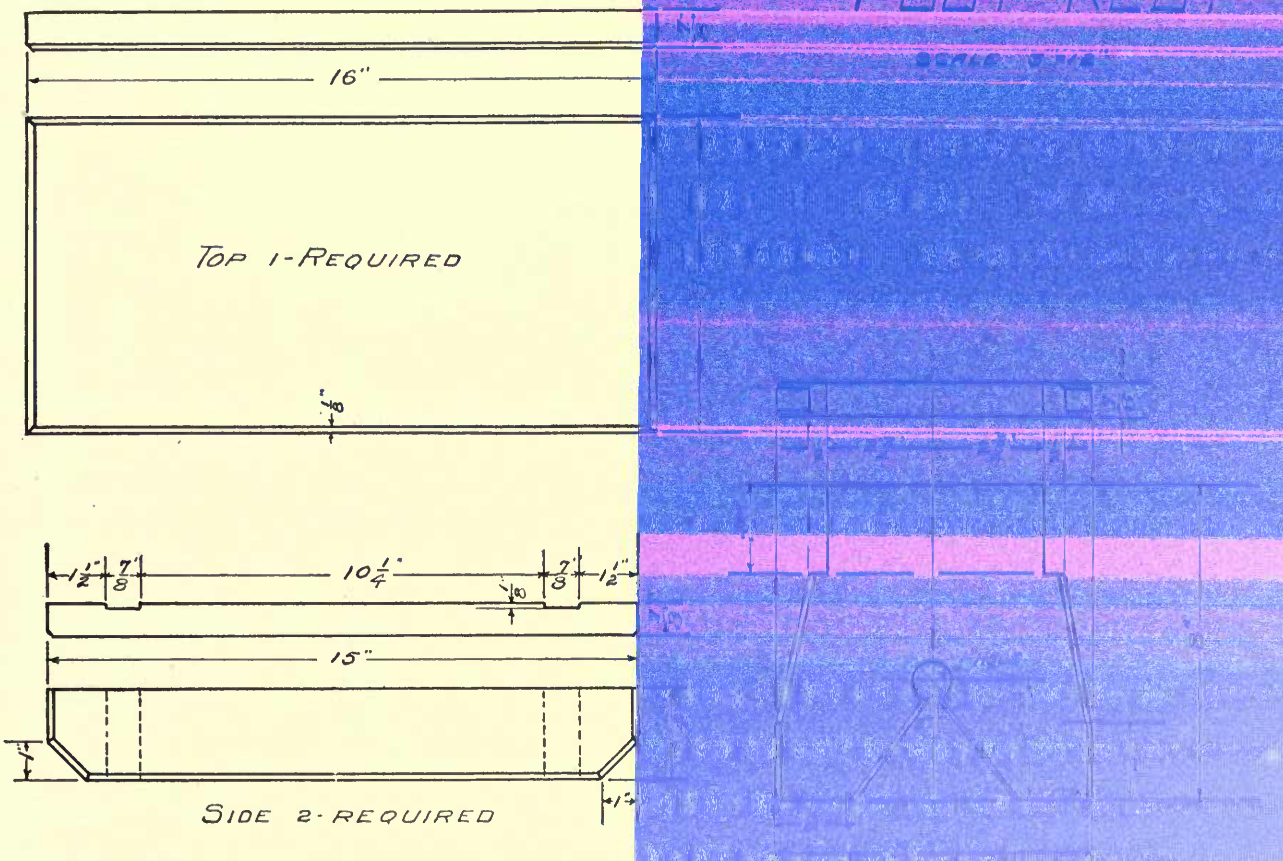
To a person accustomed to working from a drawing this practice is not at all confusing, while its saving in time and space in drawing is very apparent.



ASSEMBLY OF FOOT REST

SCALE HALF SIZE

DETAIL OF
FOOT REST



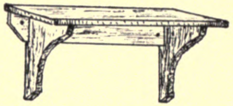
SHELF, SLEEVE IRONING BOARD, MAIL BOX, BOOK AND MAGAZINE RACK

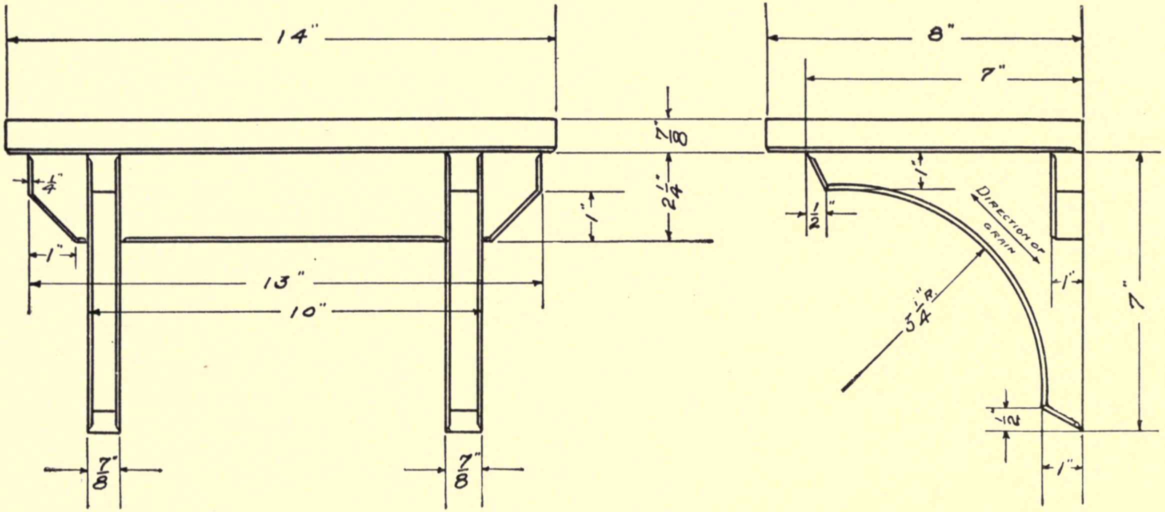
The drawings of the objects mentioned above will require two separate sheets for each, one for the assembly and one for the details. It is not essential that they be drawn to one scale. Any convenient scale or scales can be used, according to the size of the part and its position on the drawing paper. It is desirable, however, to make all drawings on the same sheet to one scale whenever possible.

By observing carefully each detailed part and locating it in the assembly, a complete knowledge of the working principles of each complete object can be obtained.

SHELF

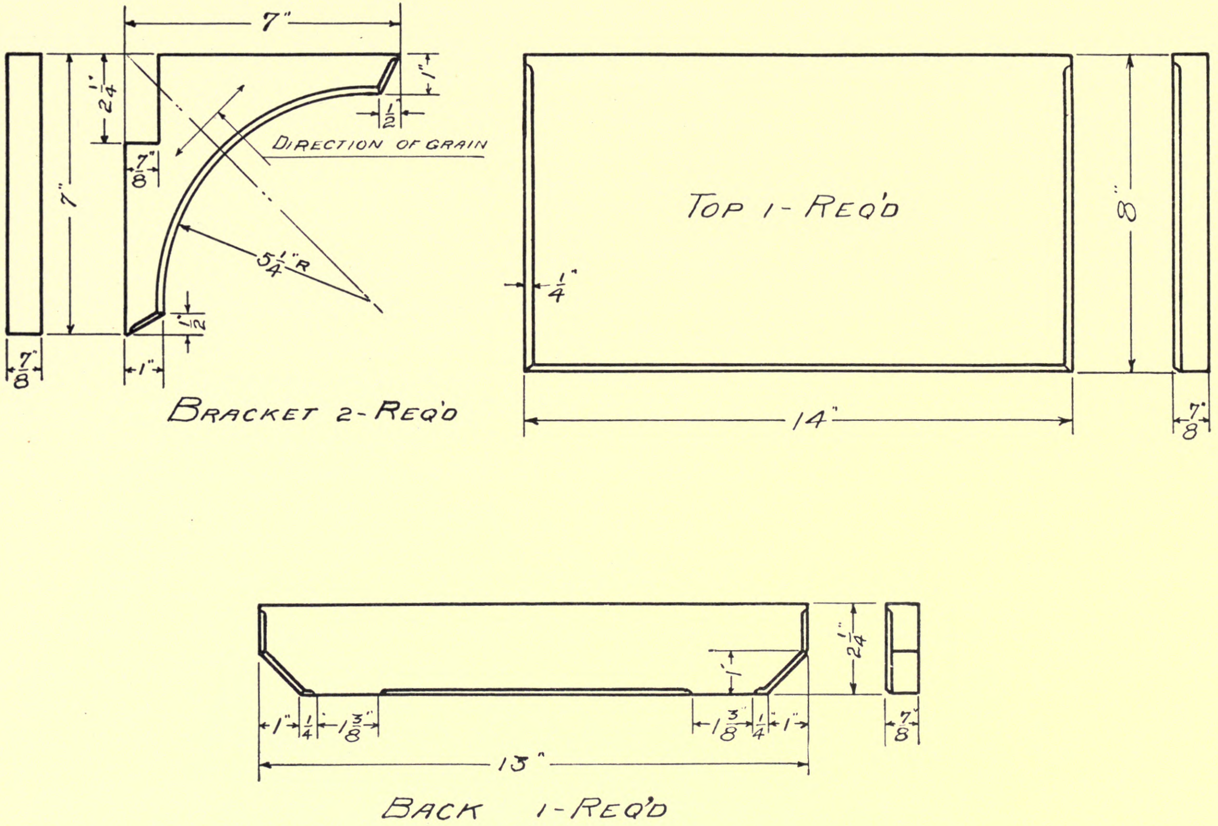
SCALE 3"=12"





HUTTON

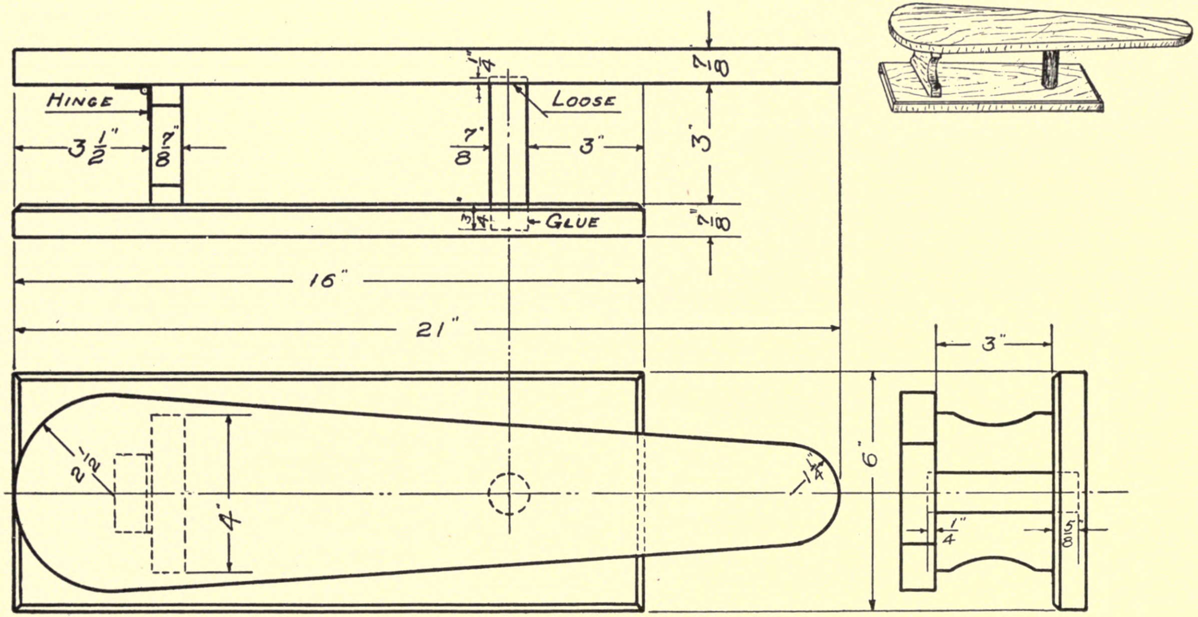
DETAIL OF SHELF



HUTTON

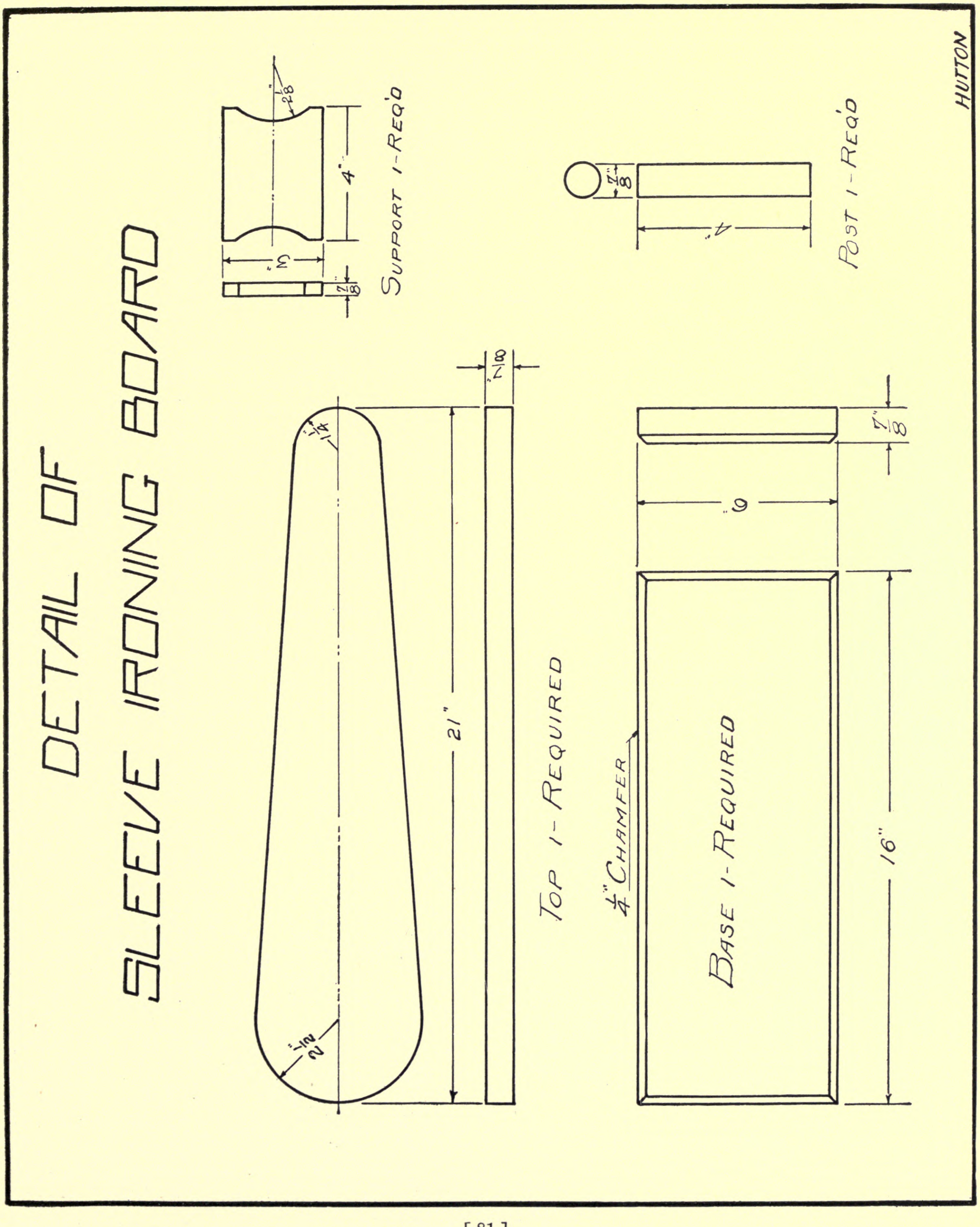
SLEEVE IRONING BOARD

SCALE 3" = 12



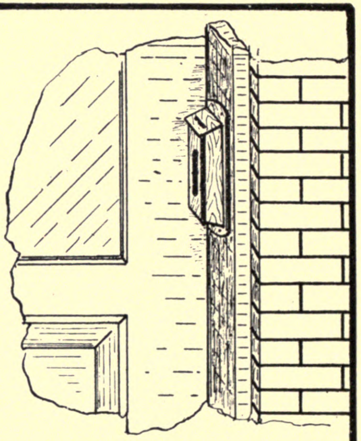
HUTTON

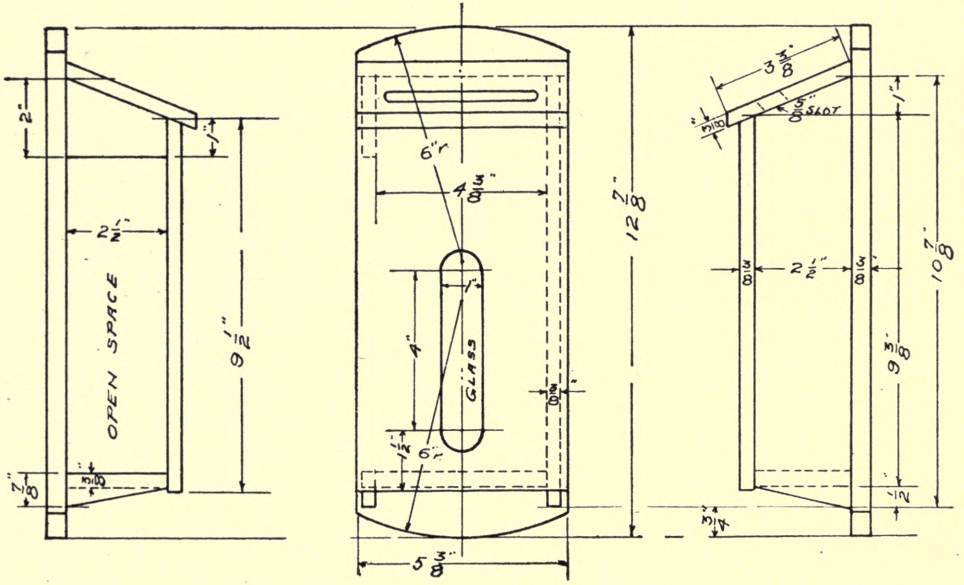
DETAIL OF SLEEVE IRONING BOARD



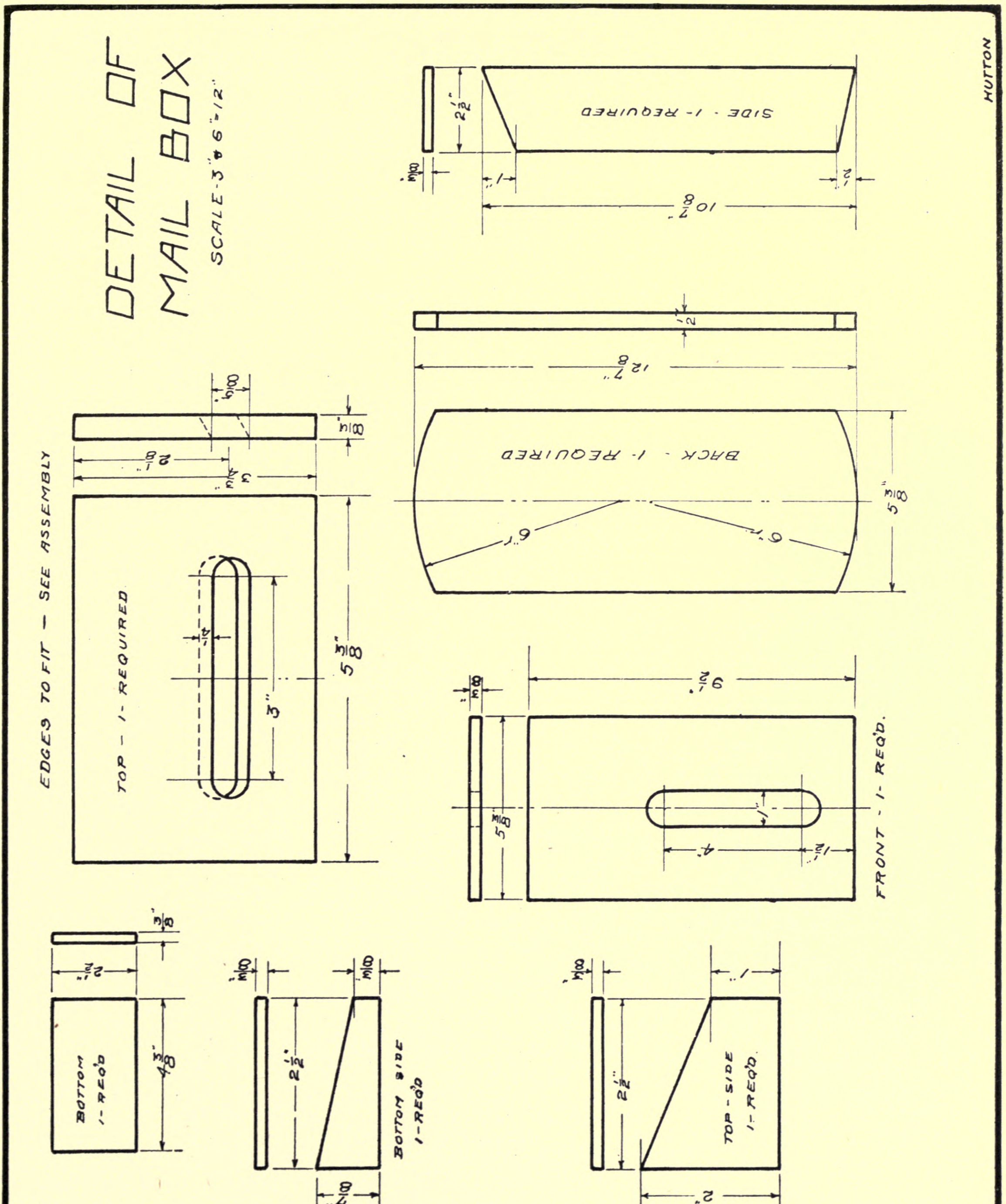
ASSEMBLY OF MAIL BOX

SCALE 3"=12"



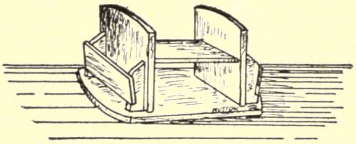


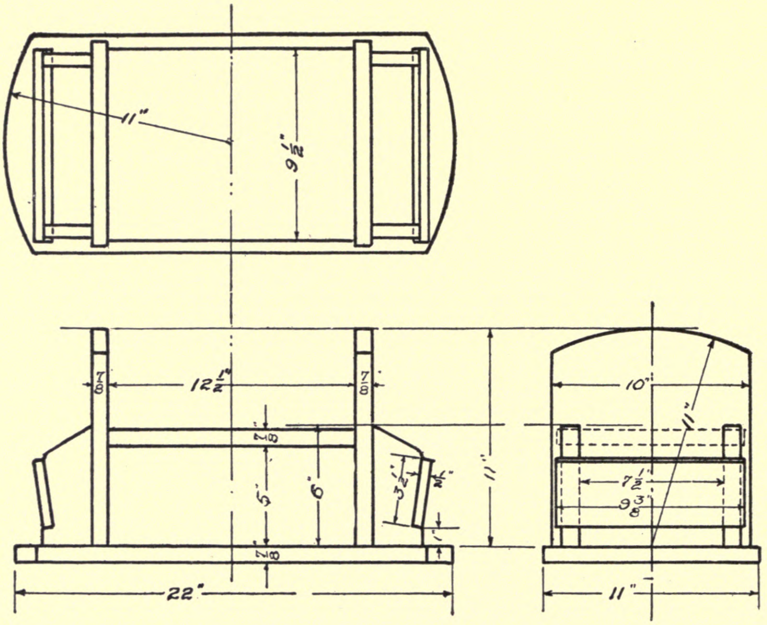
HUTTON


DETAIL OF
MAIL BOX
SCALE-3" & 6"=12"
HUTTON
SIDE - 1 - REQUIRED
BACK - 1 - REQUIRED
TOP - 1 - REQUIRED
EDGES TO FIT — SEE ASSEMBLY
FRONT - 1 - REQ'D.
BOTTOM 1 - REQ'D
BOTTOM SIDE 1 - REQ'D
TOP - SIDE 1 - REQ'D.
10 7/8"
12 7/8"
2 1/2"
5 3/8"
9 1/2"
4 3/8"
3 1/4"
2 1/8"
2 1/4"
3"
4"
1"
2"
6"
3/8"
7/8"
1/4"
1/2"

ASSEMBLY DRAWING

SCALE 1½" = 12"



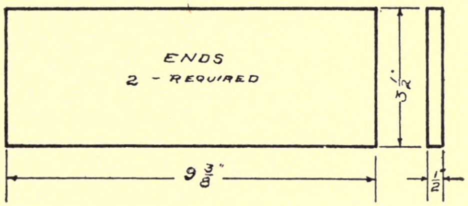


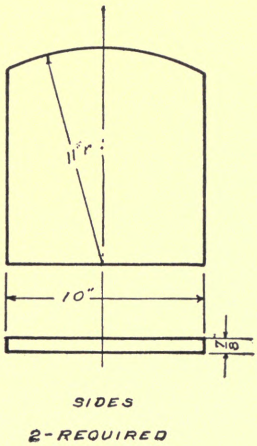
COMBINED BOOK AND MAGAZINE RACK

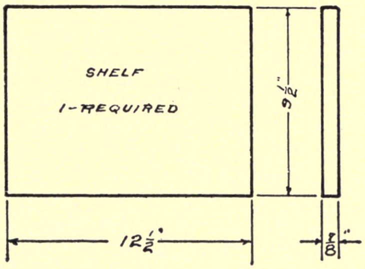
HUTTON

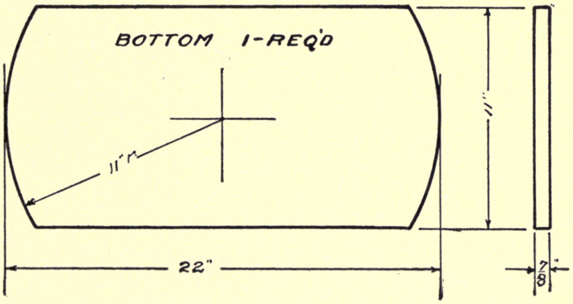
DETAIL OF COMBINED BOOK AND MAGAZINE RACK

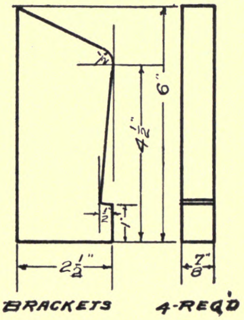
SCALE 1½" AND 3" = 12"











HUTTON

PEDESTAL

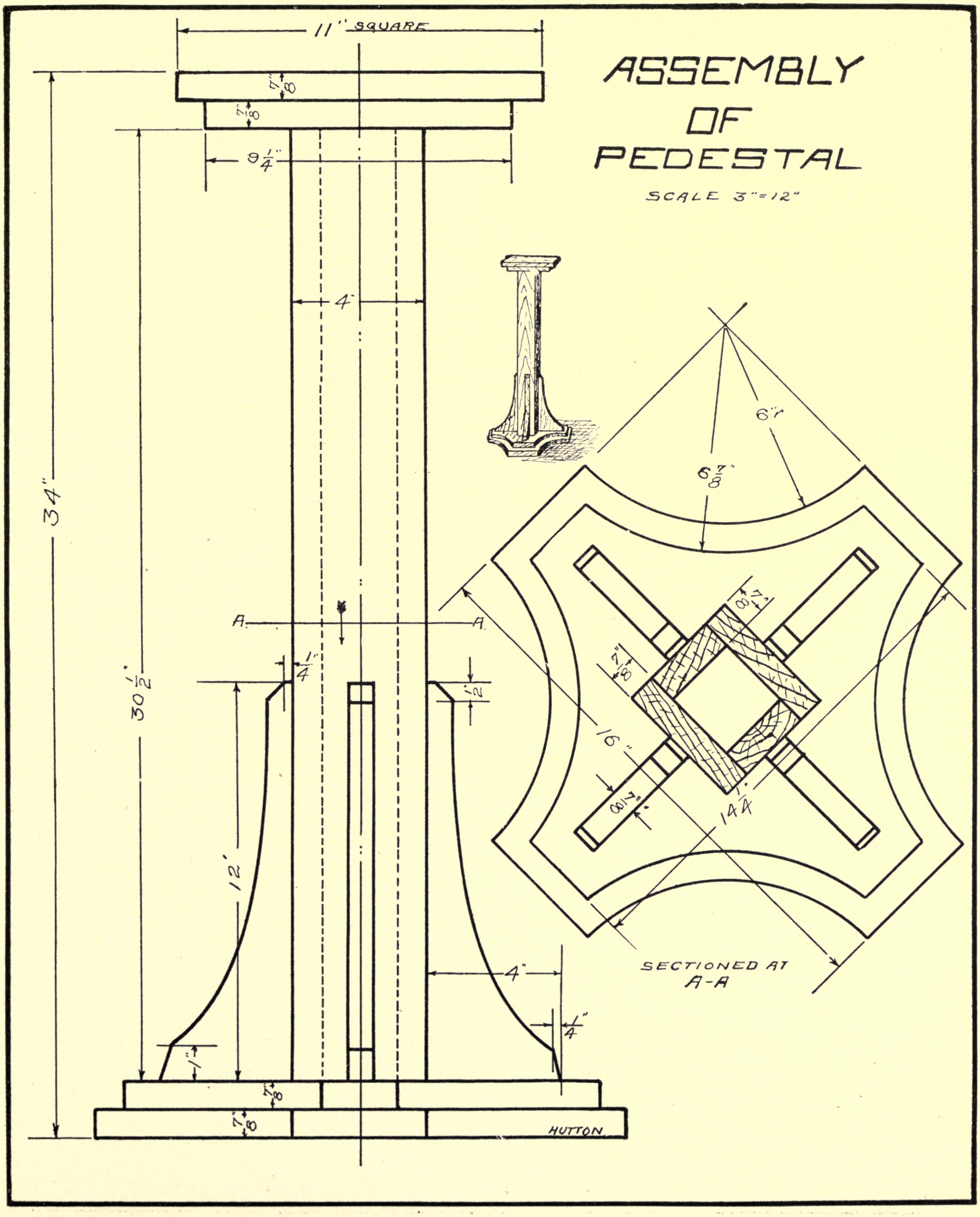
Since the Pedestal is of considerable size, and since it is square, it will be necessary to draw only the front view, aside from the section, to show clearly the shape of the base. The base could of course be shown in a top view, but in that case it would be necessary to represent a portion of its outline by dotted or hidden lines, as in this view it would be in direct line with the top.

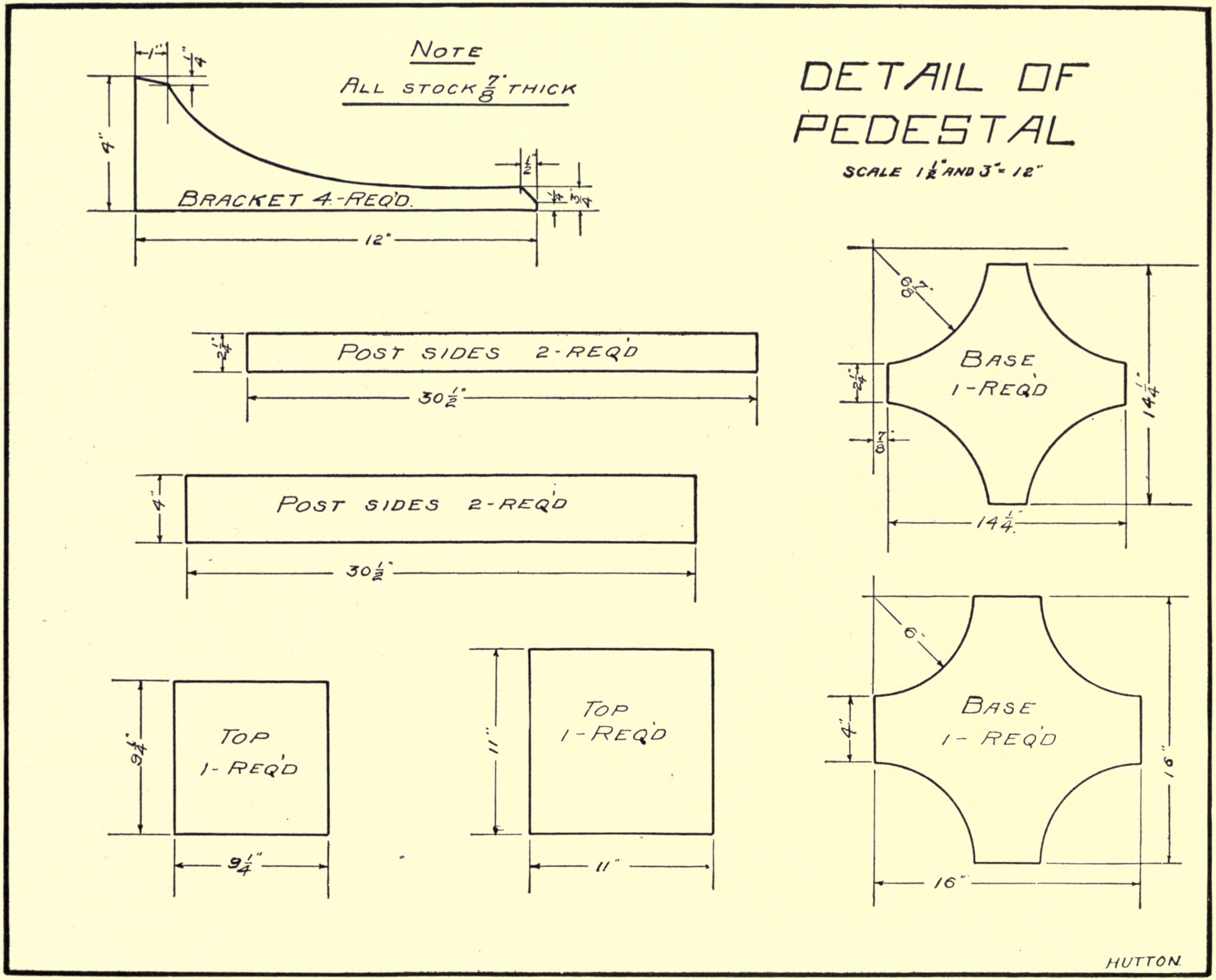
Representing the base in the manner shown not only gives a clear outline of the base but shows also the box construction of the post as well as a full top view of the brackets.

As previously explained on page 54, an imaginary cut must be made in the pedestal at points A, A, enabling a correct top view of the lower remaining section to be drawn.

ASSEMBLY OF PEDESTAL

SCALE 3" = 12"





DETAIL OF PEDESTAL

SCALE 1½" AND 3" = 12"

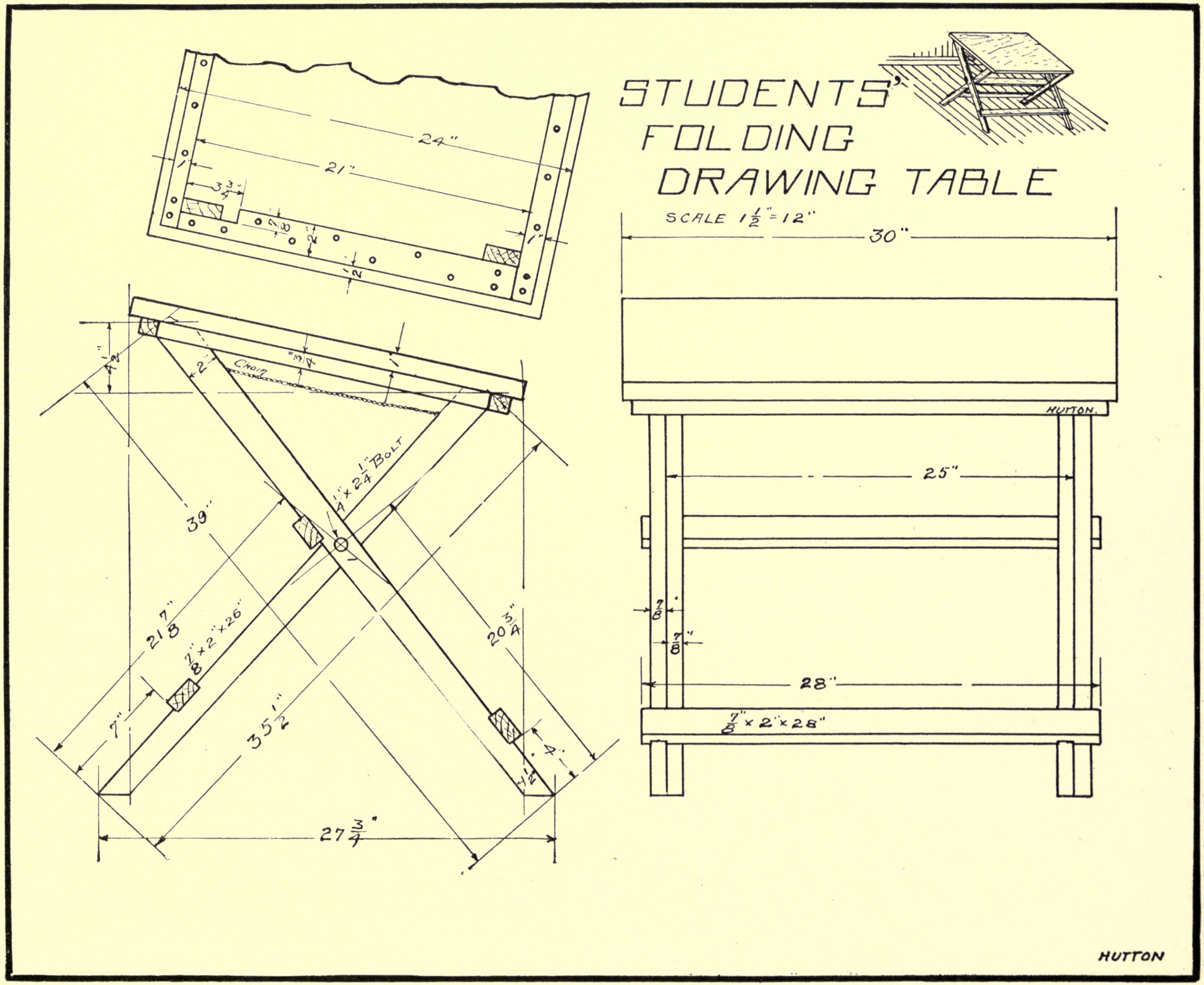
STUDENTS' FOLDING DRAWING TABLE

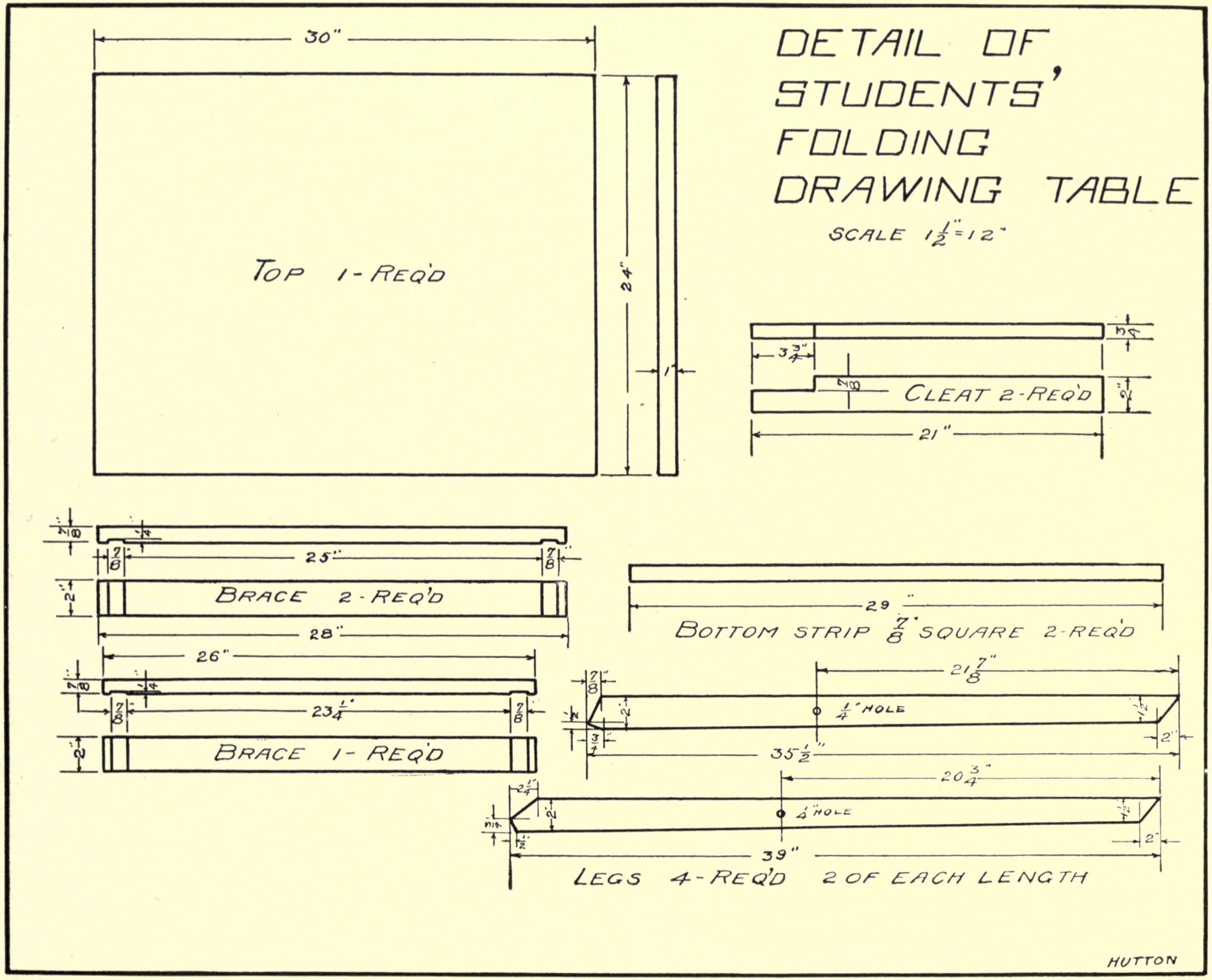
In the top view of the Drawing Table it will be noted that the under side is shown in full lines, which is exactly contrary to all principles heretofore given regarding hidden lines.

This is permissible, however, when such a view does not conflict with the clear representation of some other part of the object. It will also be noticed that the top view is drawn parallel with the top of the table which is on a slant. This is done to show the under section of the top in its true dimensions. If the top were shown directly above the front, a foreshortening of the top in the top view would be the result. The greater the slant given to the table top, the greater would be the foreshortening.

STUDENTS' FOLDING DRAWING TABLE

SCALE 1½" = 12"




DETAIL OF STUDENTS' FOLDING DRAWING TABLE
SCALE 1½" = 12"
30"
TOP 1-REQ'D
24"
1"
3¾"
¾
⅞
CLEAT 2-REQ'D
2"
21"
⅞
¼
25"
BRACE 2-REQ'D
2"
28"
29"
BOTTOM STRIP ⅞" SQUARE 2-REQ'D
26"
23¼"
BRACE 1-REQ'D
21⅞"
¼" HOLE
½
2"
¾
35½"
20¾"
2¼"
39"
LEGS 4-REQ'D 2 OF EACH LENGTH
HUTTON

INKING AND TRACING

Inking

If an entire volume were to be written on the use of drawing ink and inking tools, a certain amount of careful inking practice would still be necessary before proper results could be obtained. Considering this fact, and believing that many who use this text will do only a moderate amount of ink work, it has been deemed advisable to give merely a few instructions and precautions which will enable the student to obtain neat and accurate results.

A quill will be found connected with the stopper of each bottle of drawing ink. This is to be used in filling the drawing pens. Never dip the pen directly into the ink. Hold the pen in the left hand in a perpendicular position, with the handle at the top; then by placing the quill filled with ink, and held in the right hand, between the points of the pen blades the ink will flow from the quill to its proper position between the blades at the point. Put no more than three-sixteenths of an inch of ink in the pen.

Make sure that not one particle of ink rests on the outside of the pen blades. If ink is left on the outside of the pen it will come in contact with the T-Square blade or the edge of the Triangle. A flow of ink will thus be started from the inside of the pen to the paper or even under the T-Square or Triangle, and an ugly blot will be the result. It is best to have near at hand a good pen-wiper[1] so that all superfluous ink on the outside of the pen can be removed before the pen is brought in contact with the paper.

After the pen has been properly filled, place the T-Square or Triangle parallel to but not quite in contact with the line to be traced. Keep the pen in a position perpendicular to the drawing paper and place the point on the line so that the back of the pen will touch the edge of the T-Square or Triangle that is to act as a guide. Never let the point of the pen touch the edge of the T-Square or Triangle, as this will immediately start the ink flowing under it.

In inking over a line keep the handle of the pen in a plane perpendicular to the paper but allow it to slant a little in the direction that the line is to be drawn.

---

[1] The pen-wiper should be a piece of material free from lint, such as the back of an old kid glove or a piece of chamois skin.

Never lay away a pen even for a few minutes without first removing all ink from between the points, as the ink dries very quickly. If it is allowed to dry it must be scraped out, and this is injurious to the pen.

By a turn of the set screw on the front side of the pen the thickness of the line can be regulated. After obtaining the right thickness by experimenting on a piece of scrap paper, commence at the top of the drawing, working downward, drawing all horizontal object lines first. Nothing must touch these lines until they are perfectly dry. Then commence at the left side to draw the vertical object lines. In doing this, work away from the wet lines. Draw all lines that are to be of the same thickness before resetting or readjusting the pen. (Be sure that the pen is always clean and free from any foreign substance.)

After all lines of one thickness are drawn, readjust the pen and proceed in the same manner to draw lines of another thickness.

In inking drawings composed of straight and curved lines it is always advisable to draw the circles or parts of circles first, as it is easier perfectly to adjust straight lines to circles than it is to adjust circles to straight lines.

TRACING

When an inked drawing is desired for exhibition purposes a good hard surfaced paper should be used; otherwise an ordinary paper can be used for pencil work, which may be traced in ink on a good quality of tracing paper or tracing cloth, from which any number of blue prints can be made. Before any inking is done on the tracing cloth, scrape from a stick of chalk a small quantity of powder and with a dry cloth rub this powder over the surface of the tracing cloth. This will remove any moisture or grease and will allow the ink to flow freely and evenly.

SHEET METAL DRAWING

In a complete execution of a drawing of any article constructed of one or more pieces of sheet metal there must be, in addition to the regular two or three view projection drawing, a drawing showing the article completely unfolded. Sheet metal constructions, as far as possible, are made from one piece of material. The laying out of one or more unfolded surfaces is commonly called a Development.

The dimensions of parts when finished and the kind of joints to be used, whether soldered, lapped, etc., are to be shown in the two or three view mechanical projections. It is from the information given in these projections that the development is drawn.

Note. Students should construct the following sheet metal problems from heavy paper or card board, no matter whether they intend making them from metal or not. This will ensure an absolute understanding of the principles involved as illustrated in the drawing.

The educational value in all pattern drawing lies more in being able properly to develop the projects as drawn than in the ability to make them from patterns developed by others. All drawings should be made by each student in the order shown.

BREAD PAN

The first problem in sheet metal drawing is a common Bread Pan with which all are familiar. It is constructed of tin with lapped corner joints. A wire is to encircle the top completely and is to be covered by a projecting portion of the sides of the pan. Allowance for this must be made in the development.

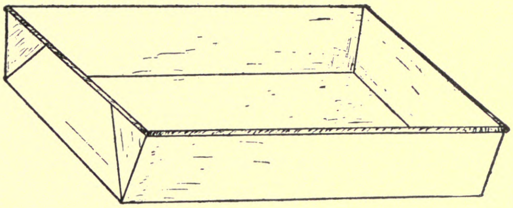
The drawing shows the pan to have a bottom 3½″ wide and 7″ long. The pan is to be 2½″ in height. The sides have a flare or slant of ½″ all around. The lap at the corners will be 1½″, and when folded or finished the top edge of this lap is to be securely held in place by the stiffening wire which is covered with the projecting portion of the sides.

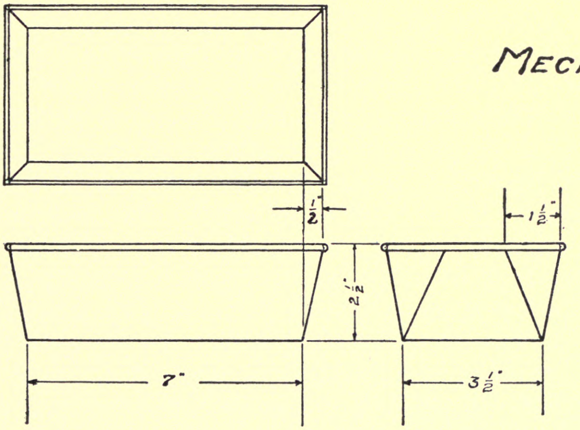
In laying out the development it is well for the beginner to distinguish clearly between the cutting, bending, and construction lines in order that he may not become confused.

In the case of the Bread Pan development shown, the full heavy line represents where the metal is to be cut, while the dotted line represents the place for bending. Light full lines represent, as usual, the construction.

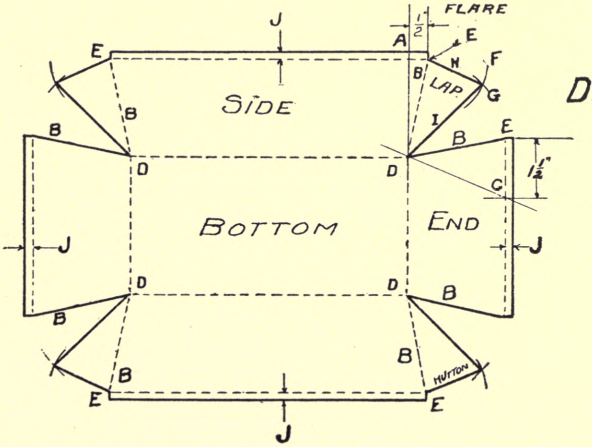
To draw the development lay out first to the dimensions shown in the mechanical drawing a rectangle representing the bottom of the pan. Set the Dividers to a distance equal to the slant height of the

BREAD PAN





MECHANICAL



DEVELOPMENT

sides and step off this distance in a horizontal direction from the ends of the rectangle just drawn. Also step off the same distance outward in a vertical direction from the sides of the rectangle. Care should be taken not to confuse the slant height with the vertical height of the pan. The height given as 2½″ is the vertical height. The slant height is taken from the bottom to the extreme top in the direction of the flaring sides of the pan in the mechanical drawing.

After these points representing the slant height of the pan are located from both sides and both ends of the rectangle in the development, draw lines through them with T-Square and Triangle parallel to the sides and ends of the rectangle. These lines, if continued outward or upward, will cross or intersect and thus form a second rectangle which will represent the exact location of the finished top edge in the developed pattern.

Extend the lines of the first rectangle until they cross or intersect the lines of the second or larger rectangle, and from these intersections, as at A, step off a distance equal to the slant or flare of the pan, which, as previously explained, is ½″. From the points just located pass lines B through the corners D.

When the work thus far described is accurately accomplished, the attention must be directed to the proper construction of the lap. This is done by extending the sides and cutting them to an angle yet to be determined, so that the upper edge of the lap when the pan is completed will lie exactly parallel to the top edge of the end of the pan.

To construct this angle a point on the top edge of the end of the pan must be located that will represent the exact position to be taken by the point of the lap when the pan is completed. The end of the pan shows the lap to extend along the top edge for a distance of 1½″ from each side. Measure off this distance on the end development as shown at C and pass a line from point C through corner D.

As this shows the exact position that must be taken by the lap when the pan is completed, triangle D E C on the end cannot be other than the exact shape of the lap to be located at the ends of both of the sides.

It is evident that the shape of this lap is triangular. It is also evident that the length of lines B on the sides and ends of the pan is the same. This being true, it is plain that the length of one side of the triangle is equivalent to the slant height of the pan or line B which has previously been located. To transfer the remaining sides of the triangle located on the ends of the pan to their true position at the ends of the sides, set the Compass to the distance C E, or $1\frac{1}{2}''$. With the point of the Compass placed at point E on the end of the sides draw the arc of a circle F.

Set the Compass to the distance D C, and with the point of the Compass on D draw arc G. From the intersecting point of arcs F and G draw lines H and I through E and D. The triangle representing the position to be taken by the lap on the end of the pan when finished is thus transferred to its correct position at the end of the sides and becomes a true outline of the lap. As the pan is of an equal height and flare on all sides the four corners will necessarily be constructed alike and can be drawn as a whole instead of singly. This simplifies the work and also makes it more nearly possible to obtain an accurate result.

The allowance necessary as shown at J for bending the metal over the reinforcing wire depends on the size of wire used.

Special attention should be given to the transferring of an angle from one position to another by means of the Compass, as this principle is extensively used in some of the problems to follow.

DUST PAN

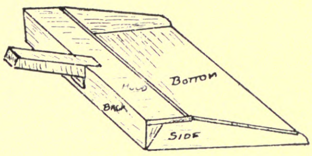
The principles involved in the development of the Dust Pan shown are practically the same as those involved in the development of the Bread Pan previously given. The exceptions are that a double angle has to be contended with, and that the back of the Dust Pan, corresponding in shape to the side of the Bread Pan, is extended to form the hood.

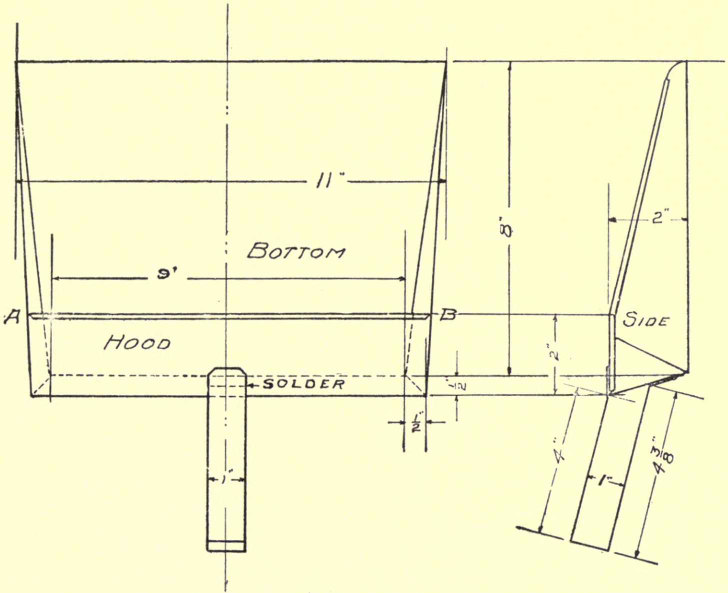
By means of a carefully executed two-view mechanical drawing the true view length of every necessary line can be located.

In constructing the development draw first the bottom of the pan, making it, as shown, 11″ wide in front, 9″ wide at the back, and 8″ deep. The vertical height of the pan is shown to be 2″, with a flare of ½″ at the top. It is necessary, then, in order to have the finished pan 2″ high, to deal only with the slant heights in the development. Therefore lay off the widths of the side and the back in the development equal to the slant height of the pan. The length of the back at its narrowest point must remain the same as the width of the bottom at the back, or 9″. As the sides and back have a flare of ½″, the extreme length of the back will be 9″ plus ½″ at each end, or 10″. As the back is a continuation of, and directly connected with the bottom, so the hood is a continuation of, and directly connected with the back. It will be noticed in the development that the length of the hood varies at different points. Being directly connected with the back, the length of one side of the hood remains the same as the length of the side of the back with which it is directly connected. The true length and width of the hood can be seen plainly in the top view of the mechanical drawing, the extreme length being A B, and the width 2″.

In order to complete the development of the sides draw a line, C D, at an angle of 90 degrees, or perfectly square with the bottom of the side, and pass this line through the point F representing the exact corner of the pan. Were the sides of the finished pan straight this line would represent the cutting line, but as they are to have a flare of ½″ it will be necessary to lay off this flare on the top edge of the pan from line C D, as shown at G. Measure off on the line representing the top edge of the side a distance equal to the width of the hood,

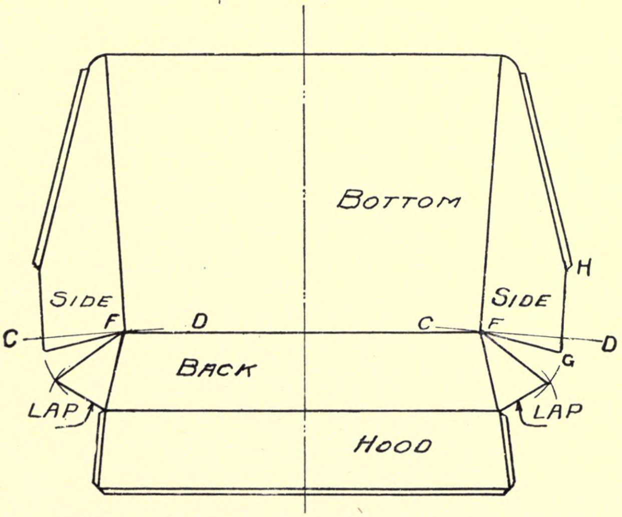
DUST PAN

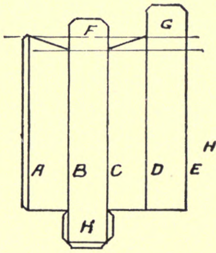




Mechanical

Development





Handle

Hutton

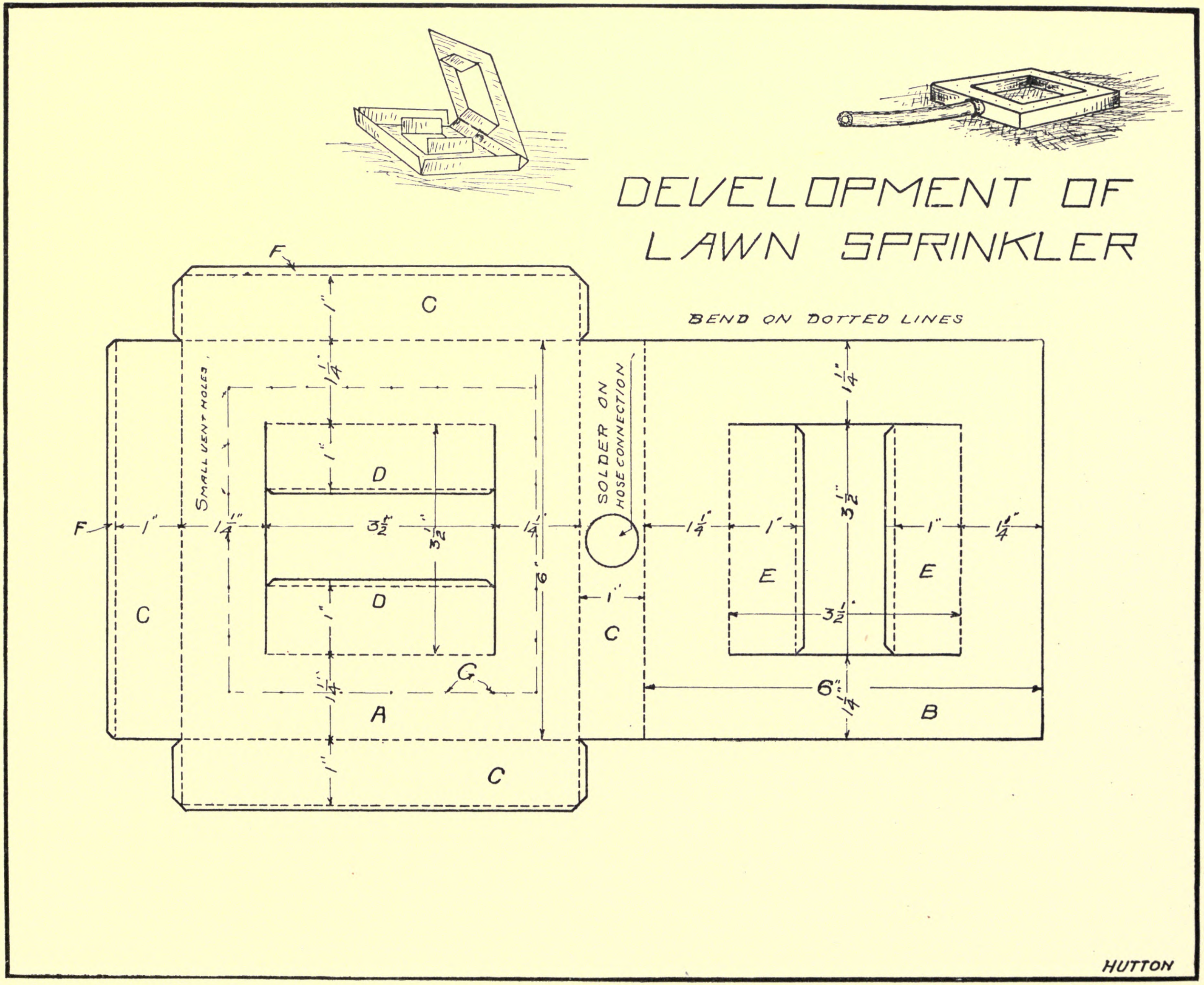
or 2″ from G to H, as this is the position to be taken by the ends of the hood in the finished pan. Lay off the lap in exactly the same manner as described for the Bread Pan and make proper allowance at the ends of the hood for soldering surface as shown. For strength and to stiffen the upper edges of the sides, a wire reinforcement should be run along the slant edges of the sides continuing in one piece along the edge of the hood.

The handle being 1″ square, the lines A, B, C, D, and E in the handle development, will be 1″ apart and parallel to each other. The lengths of these lines, as shown in the side view, are to be: A, 4⅜″; B, 4″; C, 4″; D, 4⅜″; and E, 4⅜″ long. Lines B and C must be extended about ½″ or ¾″, and lines D and E also so as to form laps F and G. These laps, when soldered to the pan as shown in the mechanical and perspective views, support the handle. The lines B and C must also be extended at the end opposite lap F, a distance of 1″, to form the closed end of the handle, H. Around this closed end and also on line A a small allowance must be made for solder contact.

LAWN SPRINKLER

The Lawn Sprinkler shown is constructed entirely along straight lines. The perspective drawing shows it to have the appearance of being constructed from square tubing, but this is not the case. If properly used, a piece of metal 8½″ wide and 14¼″ long will be sufficient to construct the top, the bottom, and all inside and outside edges.

The general dimensions show the sprinkler to be 6″ square and 1″ deep, and the opening in the center to be 3½″ square. The section marked A is the top; B is the bottom; C, C, C, C are the four outside edges which are to be bent upward; D, D are the two inside edges which are also to be bent up. E, E when bent up, and the bottom, B, bent over in place, form the remaining inside edges. All joints are supposed to be soldered, and a small allowance is made on one section of each joint for a lap, F, to aid in giving more contact surface for the solder. All laps are to be on the inside and a hose coupling is to be soldered on the side as shown. The perforations in the top, marked G, must be punched carefully and not be over $\frac{1}{32}$″ in diameter.



DEVELOPMENT OF LAWN SPRINKLER

WATER PAIL

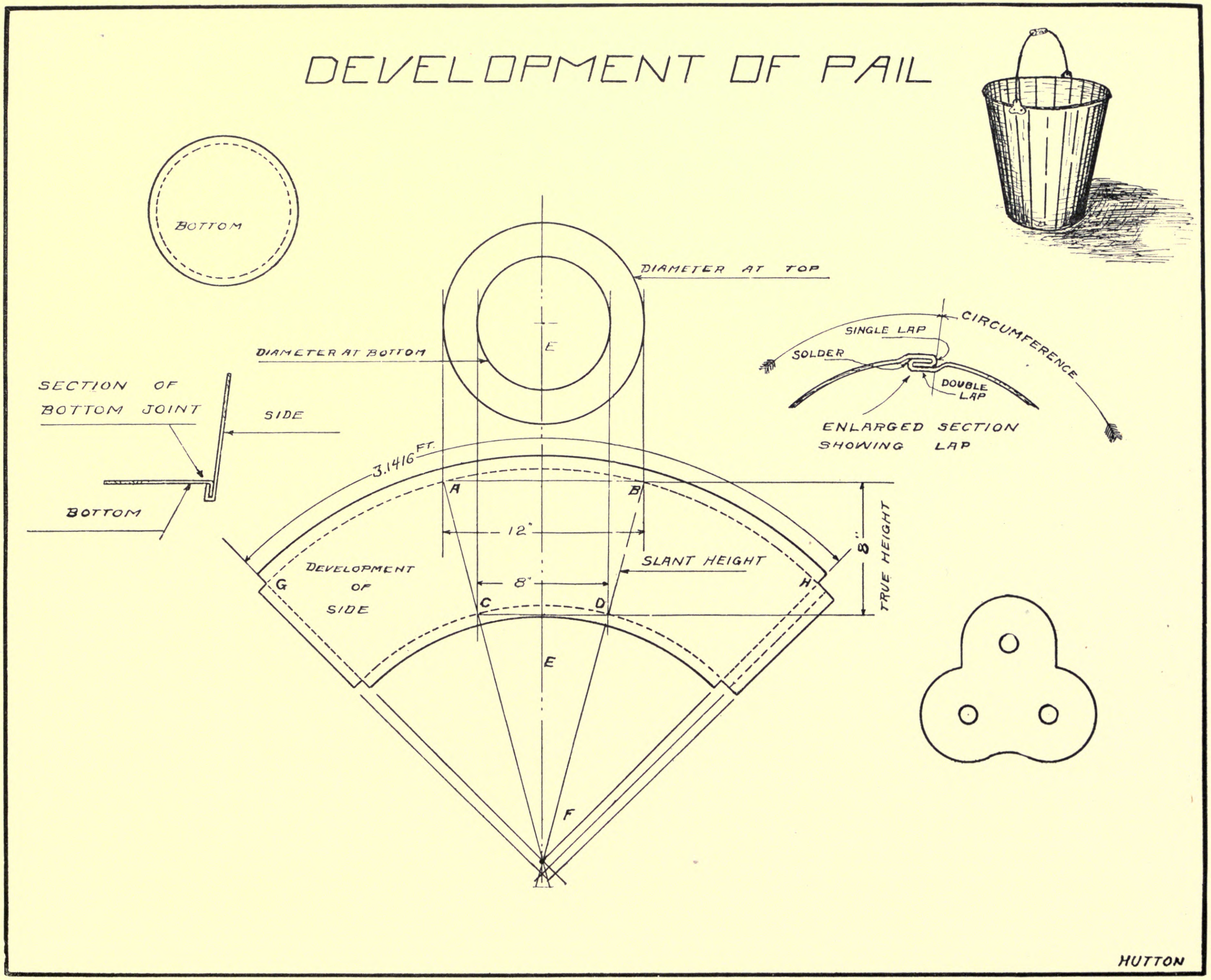
The Water Pail shown is 12″ in diameter at the top, 8″ in diameter at the bottom, and 8″ high. It is necessary, to get the development of this pail, to draw an exact view (A, B, C, D) with a vertical line E passing through its exact center. Extend the lines A C and B D, representing the sides of the pail, downward until they cross each other on center line E at point F; set the Compass at point F and draw an arc of a circle through points A and B. From the same center draw the arc of a circle through points C and D. Compute the circumference of the pail at the top and locate this distance on the first arc drawn so that the half of this distance will lie on each side of the center line E, as at G and H.

Note. A very convenient plan for locating the proper circular length (or circumference of the pail at the top) on the development of the side of the pail, is to draw a circle of proper diameter on a piece of card board and to cut it out with a pair of scissors. The required distance can then be easily measured along the edge of the card board with a tape-line and transferred to its proper position on the drawing, with a pair of dividers.

Draw a line through center F and point H, also one through center F and point G. This will determine the angle of the cuts to be made. The circumference of the bottom of the pail will not have to be computed, as the proper points on the second arc, representing the bottom of the pail, have been automatically located by the intersection of this arc with the lines passing through F H and F G. The pail will, of course, have a wire reinforcement around the top, and the proper allowance for tin must be made according to the size of the wire used.

A little study must also be given the method of inserting the bottom and of joining the sides to it so that the completed pail will not vary from the original dimensions.

In the drawing showing the enlarged section of the lap joint it will be seen that a double allowance must be made on one end of the pattern for the side of the pail, while on the other end but a single allowance will be necessary. These lines representing the allowances must be drawn parallel with lines H F and G F, and will not, therefore, pass through center point F. The development of the bottom will be 8″ in diameter, as given, with the necessary allowance for the bend, as shown in the enlarged drawing of the bottom.


DEVELOPMENT OF PAIL
BOTTOM
DIAMETER AT TOP
DIAMETER AT BOTTOM
E
SECTION OF BOTTOM JOINT
SIDE
BOTTOM
3.1416 FT.
A
B
12"
C
D
8"
SLANT HEIGHT
DEVELOPMENT OF SIDE
G
H
8"
TRUE HEIGHT
E
F
CIRCUMFERENCE
SINGLE LAP
SOLDER
DOUBLE LAP
ENLARGED SECTION SHOWING LAP
HUTTON

SUGAR SCOOP

For the development of the Sugar Scoop it will be necessary to have an end and side view drawn. The curve shown in the side view represents the shape of the finished scoop from a side view. It may be drawn to accord with the individual taste of the designer. As the end and back views are represented by circles of the same diameter it does not make any material difference which is named the end or which is named the back.

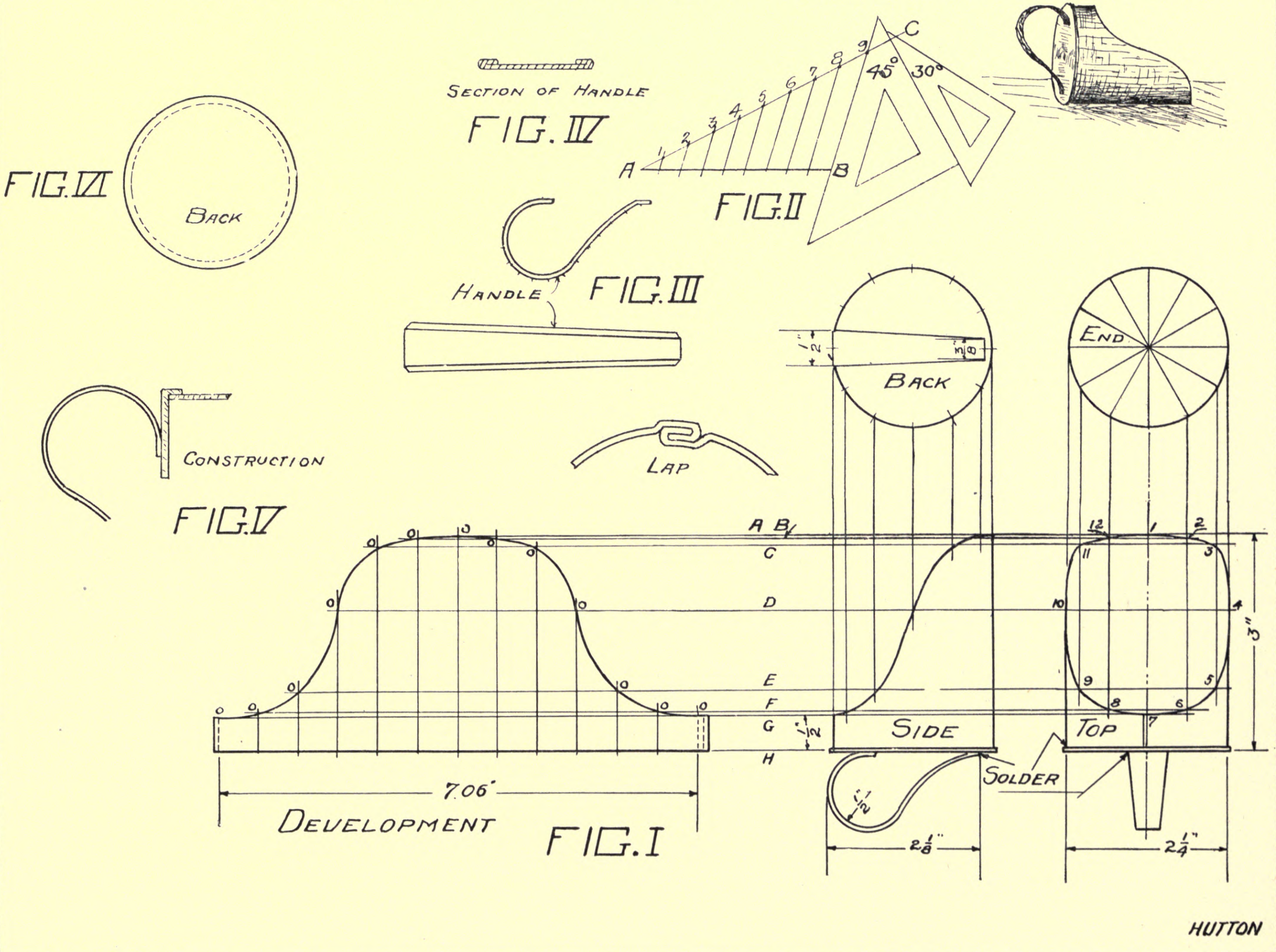
The only real value of a back view is to have a space that does not conflict with the rest of the drawing on which to show the proper location of the handle. This view gives the true widths of the handle at its extreme ends.

Divide the circles representing the back and end views, shown directly over the side and top views, into an even number of equal parts. (In this case twelve will be sufficient.) Project these division points downward and through the side and top views as shown. Through the intersecting points of these projected lines and the curve of the side view draw horizontal lines A, B, C, D, E, F, and G. Through the intersecting points 1, 2, 3, 4, etc., of lines A, B, C, etc., and the lines projected from the division points on the circle representing the end view, pass a curved line representing the opening in the front of the scoop shown in the top view. This should be done with the Irregular Curve as described on page 14.

To draw the development of the scoop (Fig. I) extend line H representing the edge of the back in the side view across the paper. On this line locate a distance equal to the circumference of the scoop, in this case 7.06″, or about $7\frac{1}{16}$″. (Calculate this circumference.) Divide this distance into as many equal parts as are in one of the circles representing the end view. Through each of these division points erect perpendiculars to A, B, C, D, E, F, G, and H; at points o, o, o, etc., as shown in Figure I, and through intersecting points o, o, o, etc., pass the required curve.

In the scoop, as in the pail previously drawn, the lap joint is used. The allowance for this joint must be twice as much at one end as at the other.

DEVELOPMENT OF SUGAR SCOOP



In Figure II is shown an easy method of dividing a given distance into any number of equal parts. Let A B represent the given line or distance to be divided. From one end draw a line, A C, at any convenient angle. With the Dividers set at any convenient distance, step off on this line as many spaces, or points—1, 2, 3, etc.—as it is desired that the given line A B be divided into. Set the 45-degree Triangle so that its edge covers point B on the given line, and point 9 on the line A C. With the 45-degree Triangle held in this position place the 30-degree Triangle so that its edge will come in direct contact with the edge of the 45-degree Triangle as shown. With the 30-degree Triangle held firmly in this position slide the 45-degree Triangle upwards, keeping it constantly in contact with the 30-degree Triangle, until the edge of the 45-degree Triangle covers point 8. Mark the point on given line A B that is crossed at this time by the edge of the 45-degree Triangle, and again slide it upward until point 7 is covered. Continue this process until all points on diagonal line A C have been covered, and it will be found that the given line A B has been equally divided into the required number of spaces.

Note. The geometrical principle involved in dividing a given line into any number of equal spaces should be dwelt upon until thoroughly understood. It is simple and accurate.

Figure III shows the side view of the handle of the scoop and gives the method of its development. This side view can be drawn from the dimensions of the handle given in the side view of the scoop. With the Dividers step off a series of spaces on the side view as shown in Figure III; then, by stepping off in a straight line the same number of spaces, an approximate length of the handle will be located. With the width of the handle given at each end as shown in the back view of the scoop and the length located, develop the handle as shown in Figure III. Figure IV represents a section of the handle showing the edges turned over. Determine the amount to be turned over and add this to each side of the development as shown in Figure III. To allow for the construction as shown in Figure V makes it necessary that allowance be made on the back (Fig. VI) for the metal to turn over and form a rim around the edge of the scoop.

FLOAT BALL

In the development of the Float Ball illustrated, the patterns for the several sections are drawn in exactly the same manner as was the pattern for the side of the pail, (page 105). It will be seen that the complete ball is composed of 6 sections, A, B, C, two of each of which are required.

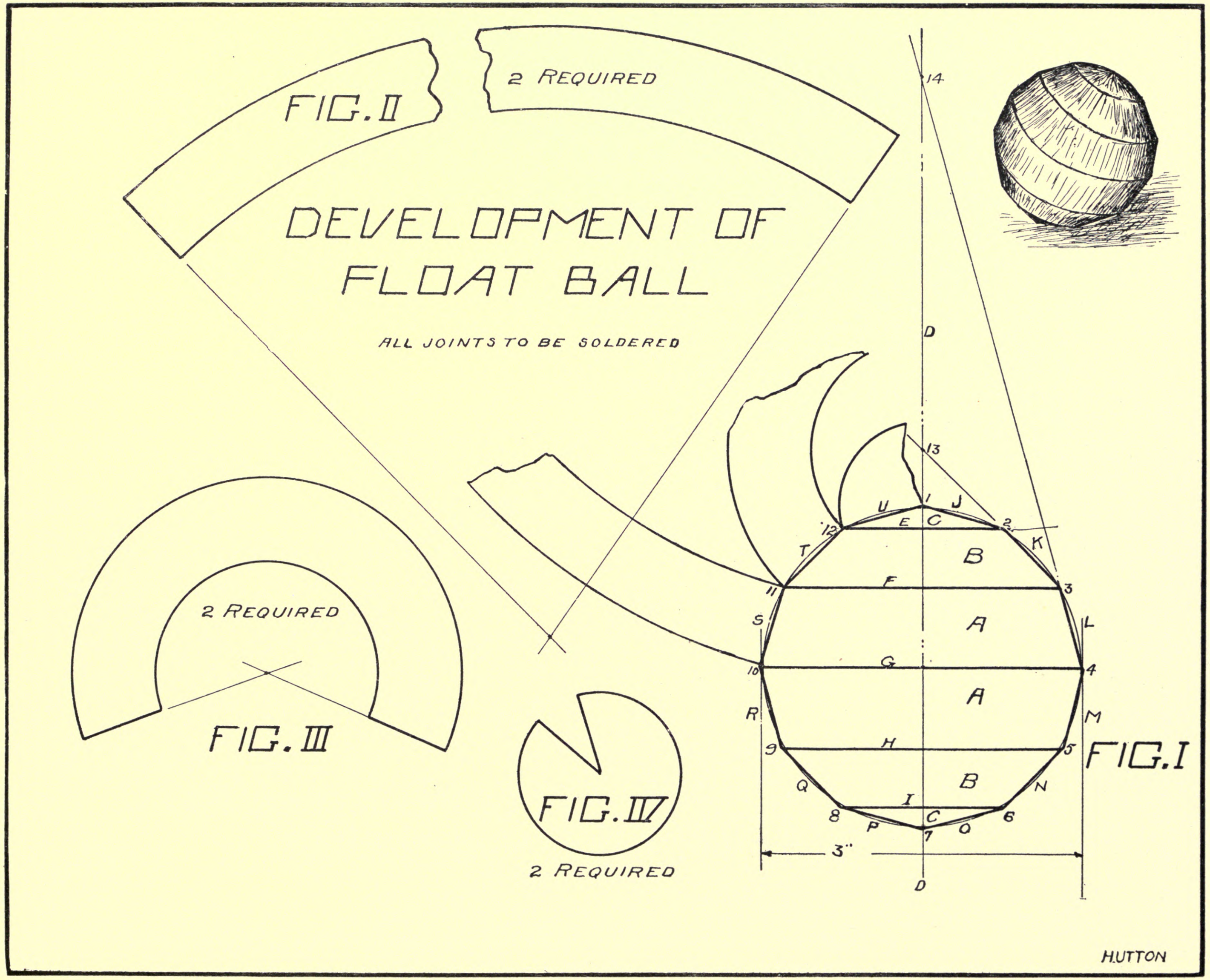
Draw, first, a circle of the proper diameter, 3″, and erect the vertical center line D. Divide the circle just drawn into twelve equal parts, 1, 2, 3, 4, 5, etc., commencing at the intersection of the circle with center line D as at point 1. Connect by horizontal lines, E, F, G, H, and I representing the edges of the sections, points 12 and 2, 11 and 3, 10 and 4, 9 and 5, and 8 and 6. Also connect points 1 and 2, 2 and 3, and 3 and 4, etc., as shown, with lines J, K, L, M, N, O, etc.

Continue lines K and L upward, as shown, until they intersect center line D at points 13 and 14, thus locating the proper radii to be used in the laying out of the different patterns, as Figures II, III, and IV. From lines E, F, G, H, and I, which are the diameters of the sections, the circumference of the ball at various levels can be computed. The outside circular length of each pattern equals the circumference of the sections just found. The slant cuts of the ends of the patterns are located by passing a line from the radial center of each pattern through the points marking its circular length, as shown in Figures II, III, and IV.

The circular length can easily be measured on each pattern by the method described in the development of the pail.

DEVELOPMENT OF FLOAT BALL

ALL JOINTS TO BE SOLDERED



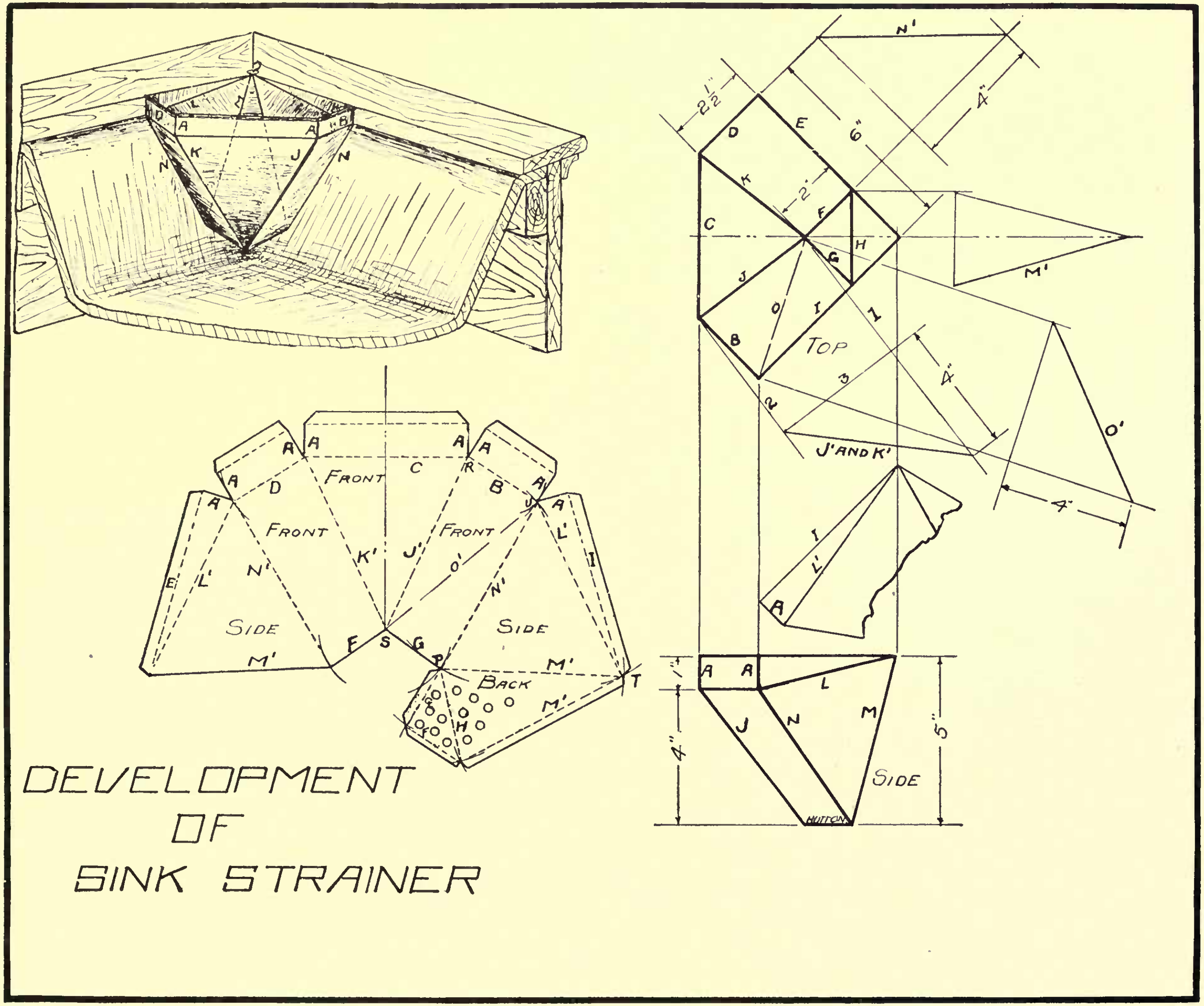
SINK STRAINER

The problem of developing the Sink Strainer is one that will require the close attention of the student. Constructed as it is, it is impossible to give the true length of all lines in two or three views, and as a development is composed entirely of true lengths it is necessary that a method for determining the true length of a foreshortened line be given and mastered.

In the side view line A, and in the top view lines B, C, D, E, F, G, H, and I are shown in their true lengths. Lines J and K of the top view represent the front corners of the strainer as shown at J and K in the perspective, but do not represent their true length; neither do lines L, M, and N in the side view. As the true lengths of all foreshortened lines can be determined in the same manner, the attention of the student is called to the method used in determining the true length of lines J and K in the top view. At a perfect right angle with line J draw the two parallel lines from each end of this line J, as lines 1 and 2. Parallel with line J, and in any convenient location, draw line 3. From the intersection of lines 3 and 1 measure off on line 1 a distance equal to the vertical height of lines J and K as shown in the side view to be 4″. Draw line J^1 K^1 connecting the intersecting point of lines 2 and 3 with the vertical height, as measured off on line 1. The true length of lines J and K will be the length of diagonal line J^1 K^1.

After locating in the same manner the true lengths of all foreshortened lines proceed to draw the development as follows:

By examining and studying carefully the side view and the perspective it will be seen that the altitude or the true height of the triangular shaped front is equal to the length of line J in the side view. So measure this height off on a vertical center line and draw line C, making half of its length lie on each side of the center line in a horizontal direction. Draw lines J^1 and K^1 (which are the true lengths of lines J and K) as shown, terminating at point S. Construct the rectangular shaped front as shown by setting the Compass to a distance equal to the length of line B, and from point R draw an arc of a circle.



DEVELOPMENT
OF
SINK STRAINER

Set the Compass to a distance equal to the length of line G, and from point S also draw an arc of a circle. In order to locate points U and P on the arcs just drawn it will be necessary to have the true diagonal length O of the rectangular front which will be found to be O^1. With the Compass set to a distance equal to the length of O^1 draw an arc of a circle from point S, cutting the first arc drawn at point U. With the Compass set at a distance equal to the length of line N^1, which is the true length of line N, draw an arc from point U, crossing the second arc at point P. Draw all bending lines as shown.

To draw the triangular shaped sides set the Compass at a distance equal to line L^1, and from point U draw an arc of a circle. With Compass set to a length equal to line M^1, which is the true length of line M, draw an arc of a circle from point P intersecting the arc drawn from point U at point T. The back and bottom are drawn in exactly the same manner. Make the proper allowance on line M^1 of the back, and also on lines F and G of the triangular bottom, for soldering surface as shown. The series of small circles shown on the bottom and back represent drain holes. The 1″ straight perpendicular top edge of triangular front C and rectangular fronts B and D are to be drawn with the edges A at a perfect right angle with lines B, C, and D.

It can be seen in the mechanical drawing, the perspective drawing, and the development that the perpendicular top edges of the triangular shaped sides are one inch high in front, tapering to nothing in the back; therefore, from point U, with the Compass set at a distance equal to the length of line A, or 1″, draw the arc of a circle, and with the Compass set at a distance equal to the length of line I, and using point T as a center, draw an arc intersecting the arc drawn from point U. From this point of intersection construct the tapering perpendicular top of the triangular side as shown.

Make an allowance around the extreme top for a reinforcing wire. This wire, while being inserted, can be made to form a loop at the extreme back top corner to be hooked over a small nail or hook placed in the corner of the sink frame, thus forming a support for the strainer.

MACHINE DRAWING

SCREW THREADS

A curved line formed by a point moving around the surface of a cylinder, and at the same time advancing at a uniform speed along its length, is called a Helix.

The distance this point advances lengthwise on the surface of the cylinder during each revolution is called the Pitch of the helix.

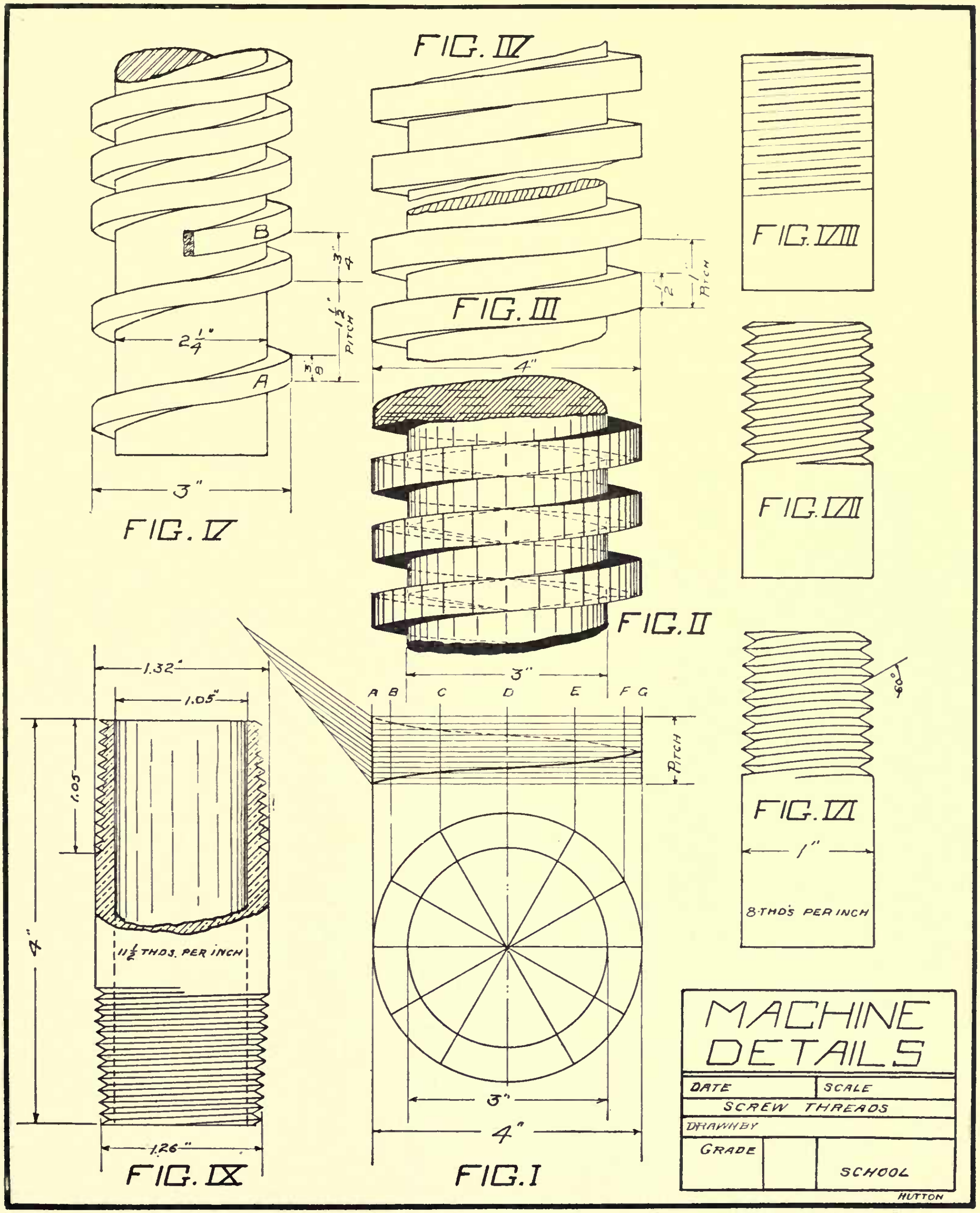
By the careful examination of a bolt and its thread it will be seen that the bolt is cylindrical in form and that the thread in passing around the bolt advances a certain distance in every revolution, thus forming a helix. The distance along the bolt that this thread travels in one revolution of the bolt is called the pitch of the thread.

The method of drawing a helix is shown in Figure I, Machine Details. The four-inch circle represents the diameter of the cylinder on which the helix is to be formed. The lines A and G projecting upwards from the horizontal diameter of the four inch circle represent a portion of the side of the cylinder. On line A lay off the distance the helix is to travel lengthwise in one revolution, or the pitch. Divide the circle into an even number of equal parts (twelve will be sufficient) and project these division points upward as shown by lines B, C, D, E, and F.

Divide the pitch that has been previously laid off on line A into the same number of equal parts (twelve), using the same method as shown in Figure II of the drawing entitled Sugar Scoop. Project these divisions horizontally from line A to line G, passing them through lines B, C, D, E, and F. By the use of the Irregular Curve, draw the required helix as shown, passing it through the intersecting points of the horizontal lines projected from the divisions on the pitch and lines B, C, D, E, and F.

In Figure II is shown a drawing of a square thread; 4″ outside diameter, 3″ inside diameter, with 1″ pitch. To show square threads in this manner requires considerable time and careful work. While it is advisable that the student understand this method it is advisable also in the problems to follow that he use the more conventional method shown in Figure III, or even Figure IV.

In Figure IV the thread is shown in a manner that necessitates the use of straight lines only. It is not theoretically correct, but for all



MACHINE
DETAILS

DATE
SCALE
SCREW THREADS
DRAWN BY
GRADE
SCHOOL

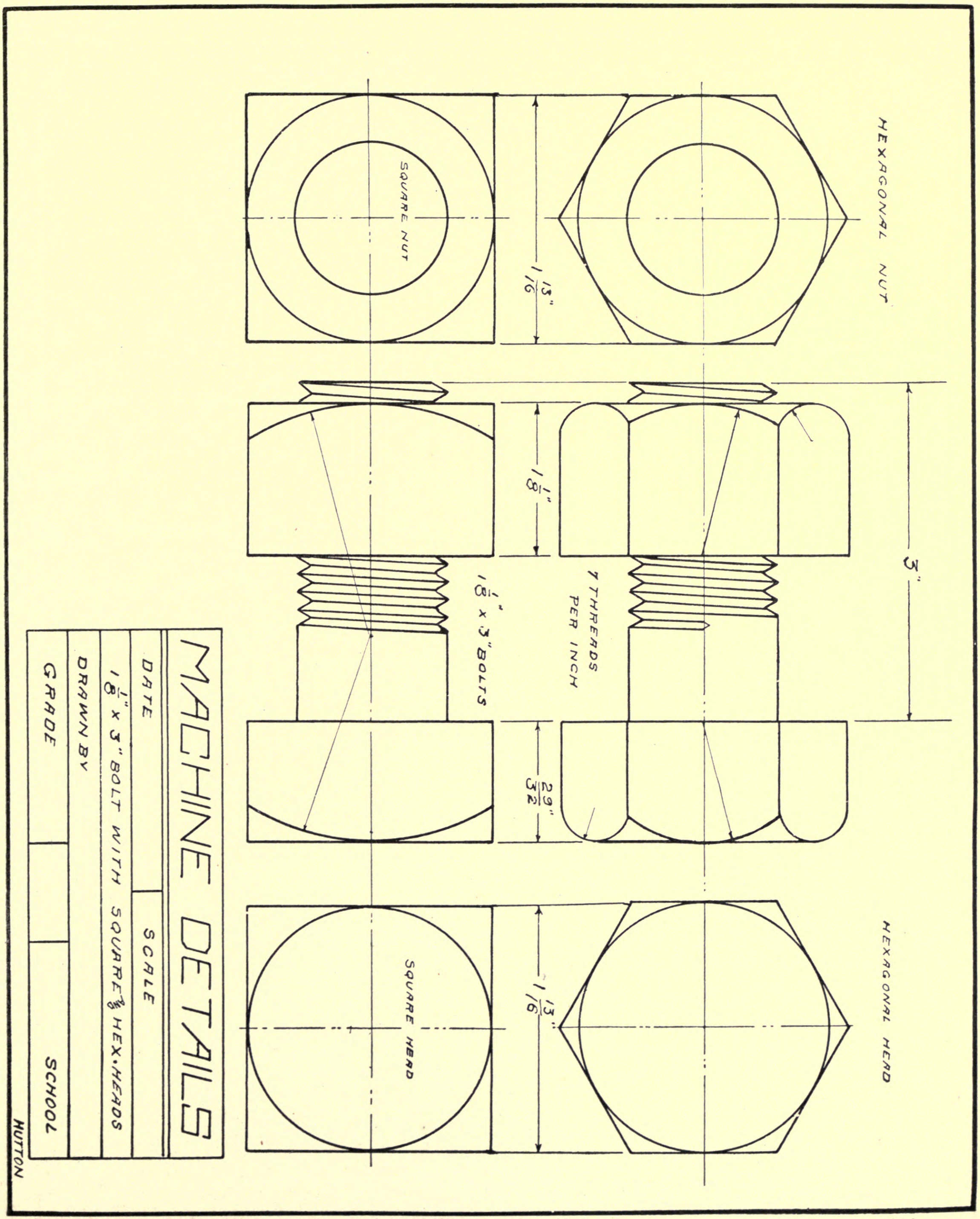
practical purposes it answers every requirement, as the diameter at the top and the diameter at the bottom of the thread, as well as the size and pitch of the thread, can all be accurately given.

At A, in Figure V, is shown a single square thread, the outside diameter of which is 3″, the inside diameter 2¼″, and the depth of the thread ⅜″ with ⅜″ face and a 1½″ pitch. This necessarily has the advantage over the thread shown in Figures II, III, and IV of being able to travel exactly twice the distance of the ordinary thread (Fig. IV) in proportion to its size. It has the disadvantage of being only one-half as strong.

To overcome this lack of strength another thread of the same size and pitch is placed between the single threads forming a double thread, as shown at B in Figure V. A bar with a double thread then has the same strength as a bar with a single thread, and has the advantage in speed, as it travels, in one revolution, exactly twice the distance, as previously explained, of a similar single thread screw. Owing, however, to the double work accomplished it requiries a double amount of power to do this work. In representing a common thread, such as is used on bolts, machine screws, etc., the conventional method shown in Figure VIII is generally used. The pitch of the thread shown in Figures VI and VII can be determined only by the required number of threads per inch; the more threads per inch the less will be the pitch. When the threads are standard the number of threads per inch can be determined from a table. The number is fixed for any one diameter of bolt or rod. In the case of Figures VI, VII, and VIII the bolt or rod is 1″ in diameter and has 8 threads per inch.

Figure IX is an illustration of a tapering pipe thread. The object of making a pipe thread tapering is to insure a perfectly air, gas, or water tight joint. As the size of a pipe is always determined by the inside instead of the outside diameter, and as it is necessary to construct a thread on a pipe so that its depth will not materially weaken the pipe, it is necessary that a standard for the number of threads per inch on a pipe differ materially from the standard for the number of threads per inch on a solid bolt or rod of the same size. This will be seen by comparing the number of threads per inch on the 1″ pipe (Fig. IX) with the number of threads per inch on a 1″ rod as in Figure VI.

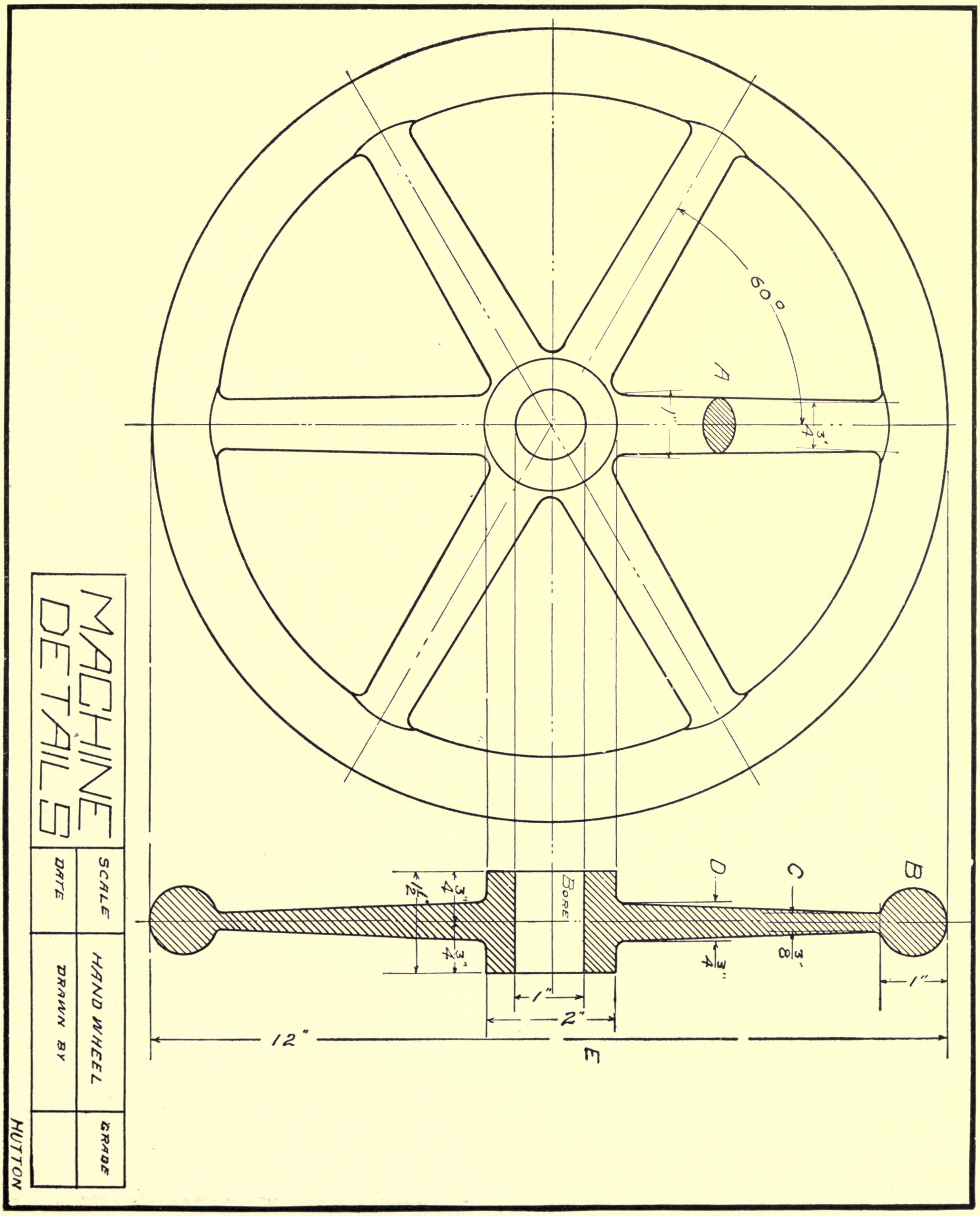
From the dimensions and dimension arcs given, the Hexagonal and Square Head Bolts and Nuts can be drawn without further explanation.

SQUARE NUT
HEXAGONAL NUT
1 13/16"
1 1/8"
1 1/8" x 3" BOLTS
7 THREADS PER INCH
3"
29/32"
1 13/16"
SQUARE HEAD
HEXAGONAL HEAD
MACHINE DETAILS
DATE
SCALE
1 1/8" x 3" BOLT WITH SQUARE & HEX. HEADS
DRAWN BY
GRADE
SCHOOL
HUTTON

HAND WHEEL

The Hand Wheel shown is such as would be used on a book-press or steam valve. The section lines show that it is to be made of cast iron. The small oval section shown in the spoke or arm at A represents the sectional shape of the arm.

The shape and size of the rim B, the thickness of the arm at rim C, the thickness of the arm at hub D, and the diameter and length of hub at each side of center E, are all plainly shown by a drawing of a sectional side view.


MACHINE DETAILS
SCALE
HAND WHEEL
GRADE
DATE
DRAWN BY
HUTTON
60°
A
B
C
D
E
BORE
12"
2"
1"
1"
1"
1½"
3/4"
3/4"
3/4"
3/4"
3/8"

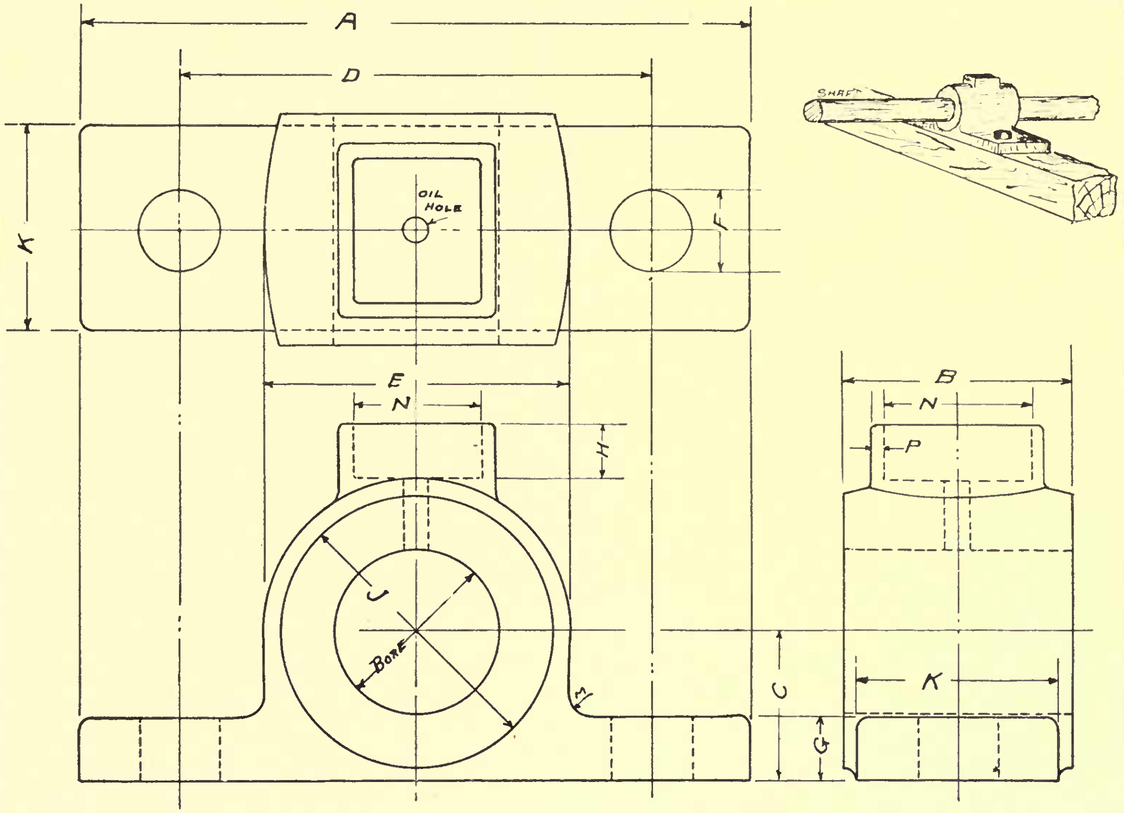
PLAIN BEARING

It is intended that the student will make drawings of the Plain Bearing in four distinct sizes. The dimensions for each bearing must all be in proportion to the diameter of the shaft for which it is to be used. It will be noticed that the diameters of the shafts for the four bearings are 1″, 1½″, 2″, and 2½″, respectively.

The general dimensions such as the length of the bearing (A), the width of the bearing (B), the diameter of the outside of the bearing (E), and the height of the center of the bore from the base (C) must be calculated by the student. Use the formulae given, which will determine all dimensions of a bearing appropriate for the diameter of the selected shaft or bore. The dimensions D, F, G, K, M, N, and P can be found at once by referring to the figures in line with the different shaft diameters and under the letter in question.

WRENCH

The Wrench is designed by the author so that from the given formulae all dimensions can be calculated for the drawings of a series of wrenches, or for the drawing of a wrench to fit any desired hexagonal nut. It will be seen that the foundation of all dimensions is the distance A, which can be determined by taking the measurements of the short diameter of the nut. Procure four or five hexagonal nuts and from the short diameters (A) of each make a drawing of a wrench for each, showing all dimensions in their proper location.

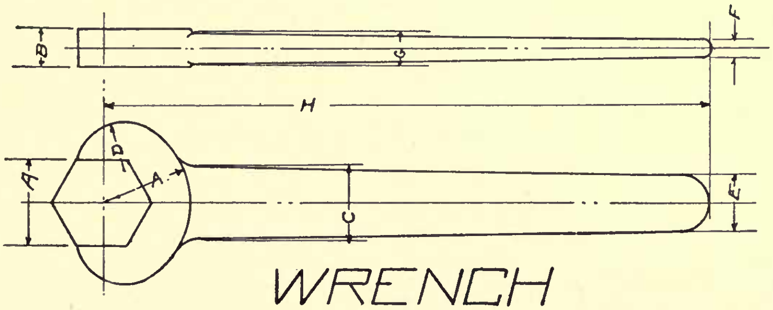


	BORE	D	F	G	J	K	M	N	P
DIA. OF SHAFT =	1"	$3\frac{9}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$1\frac{3}{4}$	$1\frac{3}{16}$	$\frac{5}{16}$	1	$\frac{1}{8}$
	$1\frac{1}{2}$	$5\frac{5}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$2\frac{3}{4}$	$1\frac{15}{16}$	$\frac{3}{8}$	$1\frac{1}{4}$	$\frac{1}{8}$
	2	$7\frac{1}{16}$	$\frac{7}{8}$	1"	$3\frac{1}{2}$	$2\frac{11}{16}$	$\frac{1}{2}$	$1\frac{3}{4}$	$\frac{3}{16}$
	$2\frac{1}{2}$	$8\frac{3}{4}$	1"	$1\frac{3}{16}$	$4\frac{1}{2}$	$3\frac{3}{8}$	$\frac{3}{4}$	$2\frac{1}{8}$	$\frac{3}{16}$

FORMULA

A = BORE × $4\frac{5}{8}$
B = " × $1\frac{1}{2}$
E = " × $2\frac{1}{8}$
C = " × $1\frac{3}{16}$

PLAIN BEARING



WRENCH

FORMULA

B	=	A	×	.5
C	=	A	×	.9
D	=	A	×	.55
E	=	A	×	.6
F	=	A	×	.3
G	=	A	×	.4
H	=	A	×	$7\frac{1}{4}$

HUTTON

MONKEY WRENCH AND WOOD WORKERS' VISE

A Monkey Wrench and Wood Workers' Vise are tools with which all are more or less acquainted.

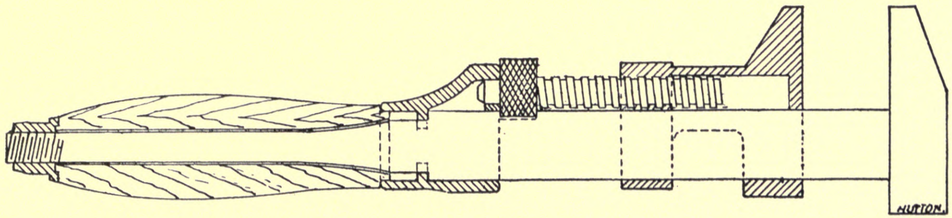
The assembly drawing of each is given in section and without dimensions. The detail drawings of these tools show each and every part dimensioned, in two or three views, as the case may be.

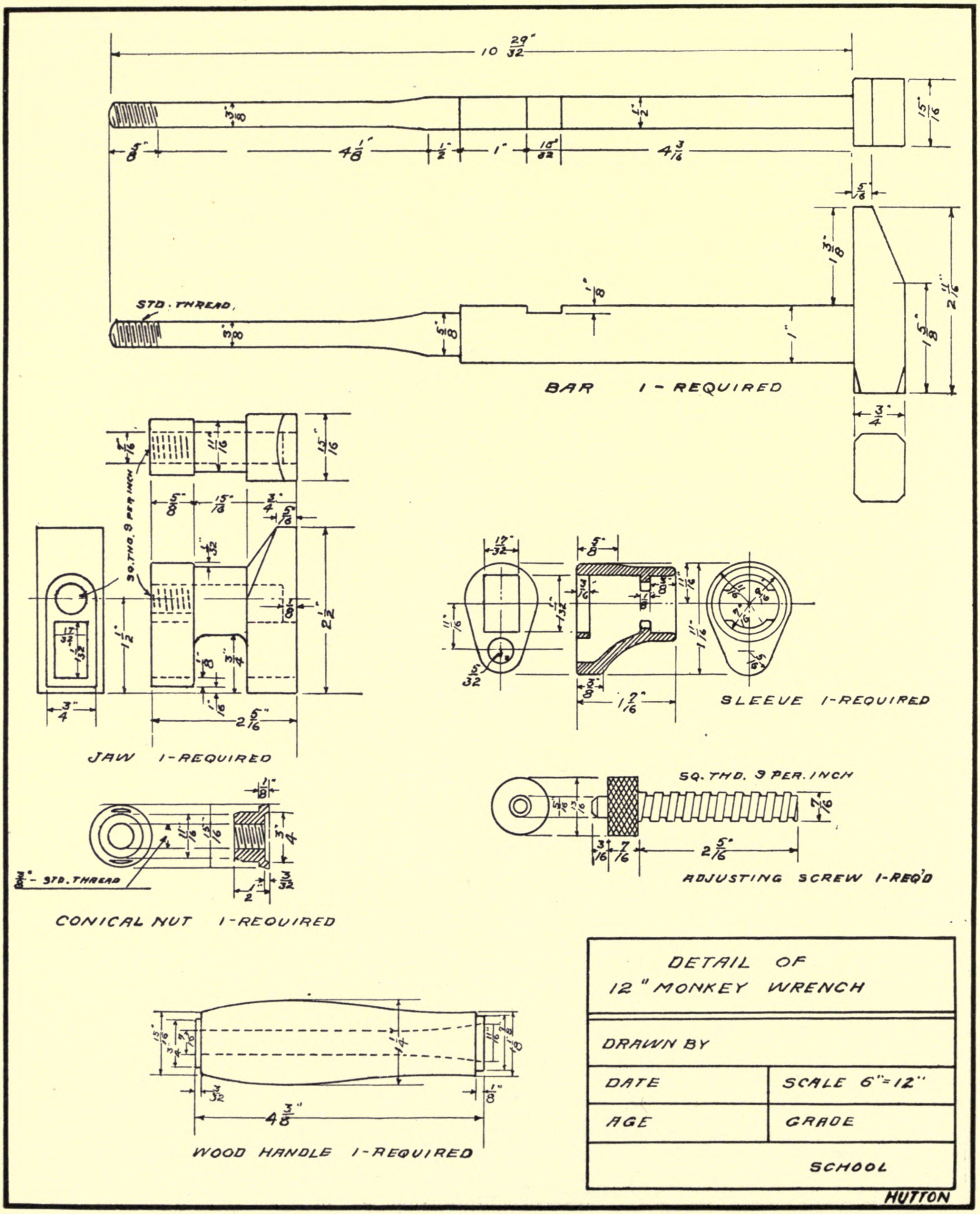
The object of showing the assembly drawings in section is to enable the student to see the exact location of each part, as well as to judge of the work each part has to perform. By referring alternately to the detail and the assembly the student can readily determine the exact shape, size, and location of each part. After the drawings have been given proper attention and study, the student will be expected to draw the sectional assembly with little or no trouble, locating the position of each part from the dimensions of the different parts given in the detail sheet.

While the same principles are involved in drawing either of these tools, the friction surface of the moving parts of the wrench need not be given the attention that the friction surfaces of the vise require, owing to the different quality of work it has to perform, and to the different class of tools to which it belongs. It will be noticed in the details of the vise that the friction surfaces, such as the beam and the surfaces of the slot in the base of the rear jaw in which the beam travels, are marked "f." This designates that these surfaces are to be finished to exact size, thus insuring a perfect surface so that the beam may be guided accurately in the direction it is to travel.

ASSEMBLY OF
12-INCH MONKEY WRENCH

SCALE 6"=12"





DETAIL OF
12" MONKEY WRENCH

DRAWN BY

DATE

SCALE 6"=12"

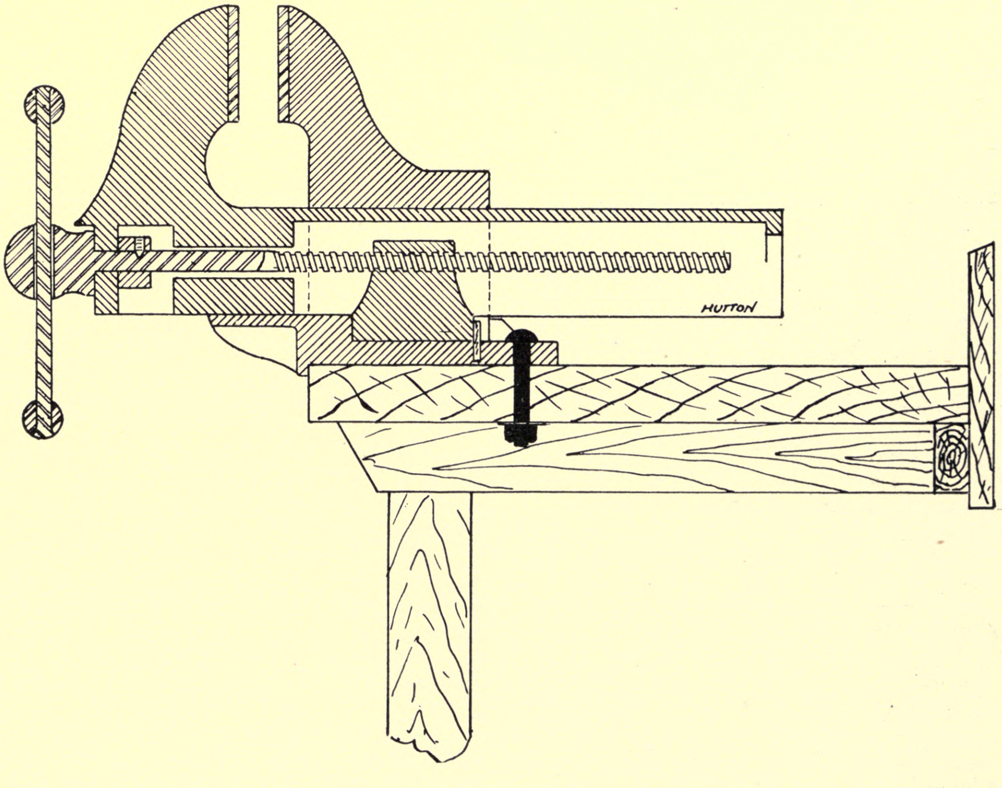
AGE

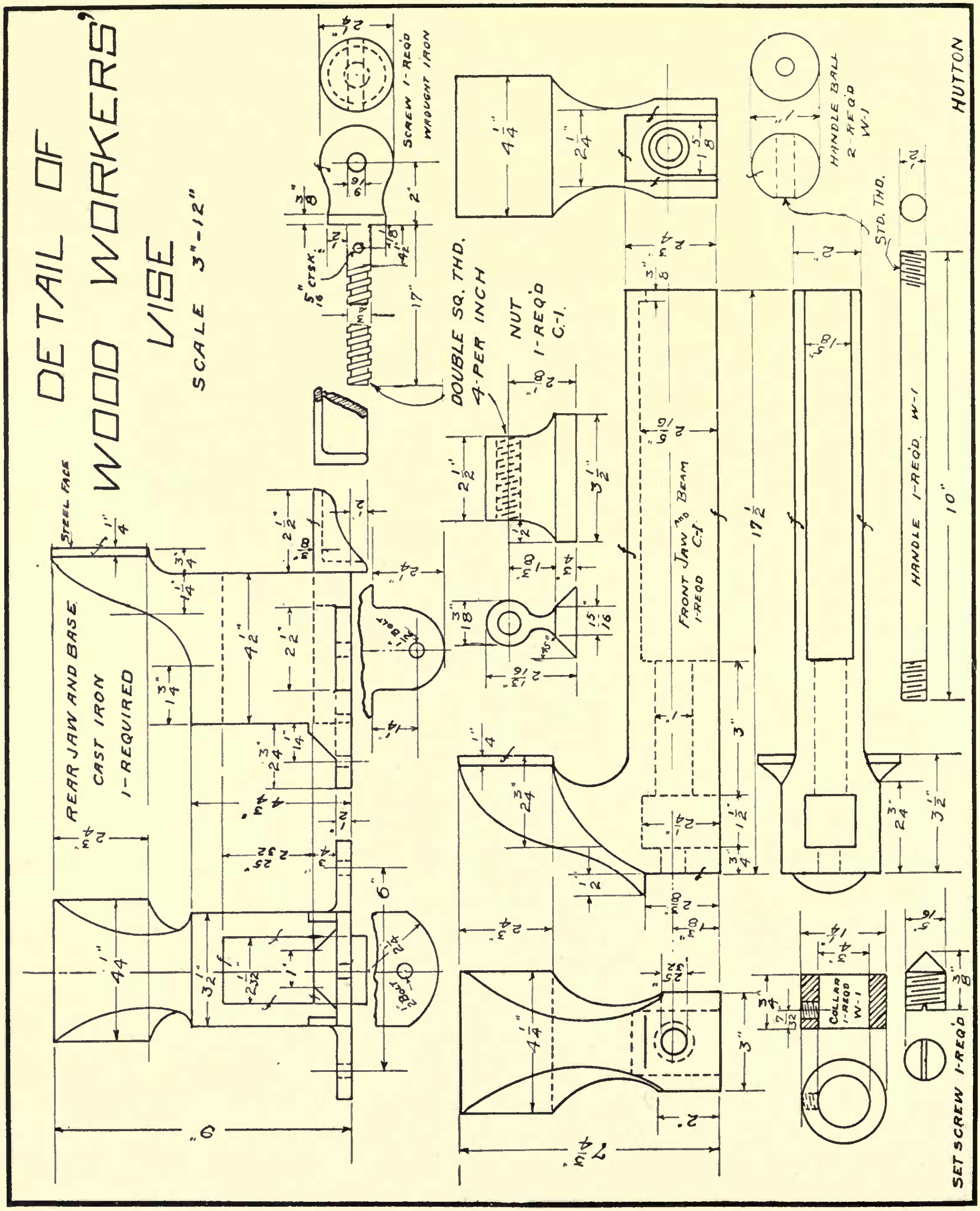
GRADE

SCHOOL

ASSEMBLY OF WOOD WORKERS' VISE

SCALE 3" = 12"




DETAIL OF WOOD WORKERS' VISE
SCALE 3"-12"
REAR JAW AND BASE
CAST IRON
1-REQUIRED
STEEL FACE
SCREW 1-REQ'D
WROUGHT IRON
5/16" CTSK.
DOUBLE SQ. THD.
4-PER INCH
NUT
1-REQ'D
C-1.
BOLT
FRONT JAW AND BEAM
1-REQ'D
C-1
HANDLE BALL
2-REQ'D
W-1
STD. THD.
HANDLE 1-REQ'D. W-1
COLLAR
1-REQ'D
W-1
SET SCREW 1-REQ'D
HUTTON
9"
6"
7 3/4"
17 1/2
17"
10"
4 1/4"
4 1/2
3 1/2
2 1/2
3"
2"
1"
3/8"

ARCHITECTURAL DRAWING

ARCHITECTURAL DRAWING

The particular Architectural Problem herein given has been selected because in it we are to cover the points in frame construction that are apt to be met with in the designing and drawing of almost any ordinary modern frame dwelling house.

In designing a dwelling house, the first and second floor plans must be drawn, practically speaking, as one unit; the inside walls for different stories in a house should, for strength, be placed, as nearly as possible, one above the other in planning the rooms on each floor. The location of chimneys must be determined so that they will not conflict with the walls, windows, etc., of the floor above or below, as the case may be.

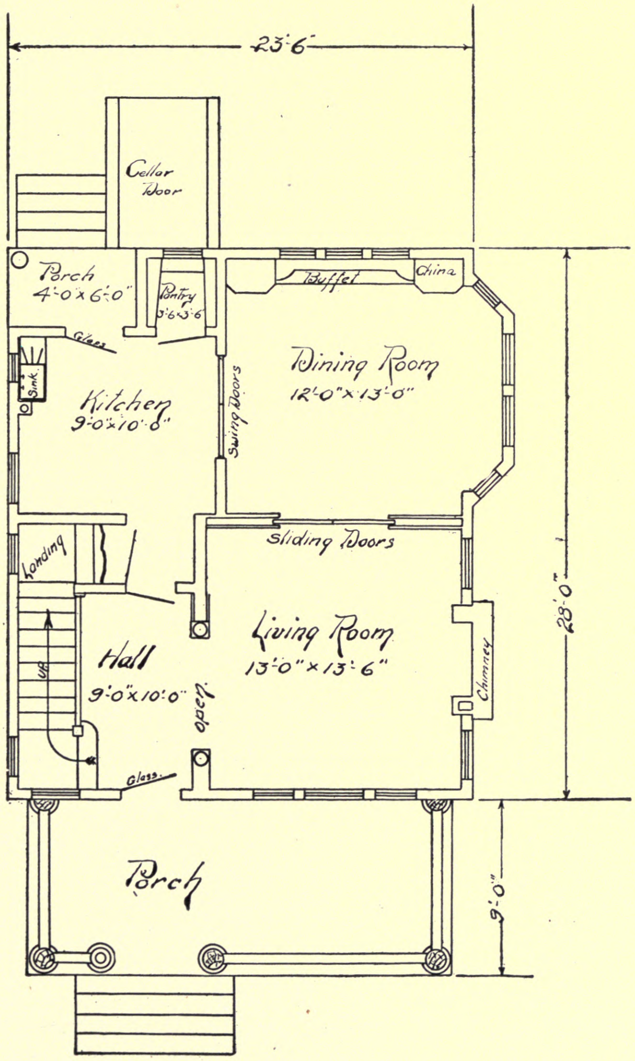
The position of the stair landings should be definitely determined as early as may be, and other inside details arranged accordingly.

The placing of the bath room and its plumbing should be, as nearly as possible, in line with the plumbing of the kitchen and laundry, so that all drainage pipes will lead directly to one point.

Ample closet accommodation should be made in all upstairs rooms, and whenever possible in the upstairs hallway.

The placing of all ordinary household furniture, such as a kitchen cabinet, kitchen table, dining room table, dining room chairs, buffet, piano, couch, beds, and dressers, should be considered as the house design proceeds, so that these articles may not interfere with windows, doors, etc. The arrangement of rooms should be made so as not to have any waste space, that is, any space that can not be conveniently utilized. The windows and doors should be placed so as to give the best light and ventilation possible.

By referring to the first floor plan it will be seen that the design of the house calls for a front reception hall 9′ × 10′, with an open stairway leading from it; a living room 13′ × 13′6″, with an open fireplace; an open space, or colonnade, between the living room and the reception hall; a dining room 12′ × 13′, with sliding doors connecting it with the living room. In the dining room there will be a bay window, built-in china closets and buffet, over which are small triple windows. The kitchen, 9′ × 10′, has swinging doors connecting it with the dining room. The kitchen contains a sink and drain board, a chimney in the wall for the accommodation of a kitchen stove or range, and a small win-



First Floor Plan

SCALE 1/8" = 12"

HUTTON

dow over the sink. A pantry 3′6″ × 3′6″ adjoins the kitchen. In the hall is an inside cellar-way. On this floor there is also a back porch 4′ × 6′.

In the second floor plan the design calls for a front bedroom, 10′ × 14′, with mantel, and a closet 3′6″ ×4′6″; an alcove 8′ × 10′, from which opens a stairway leading to the attic; two back bedrooms, one 8′ × 8′, the other 10′ × 12′6″, in each of which is a closet 1′6″ deep × 4′ wide; and a bathroom 4′6″ × 8′, to be provided with a small window on the outside wall. Just outside of the bathroom partition is the kitchen chimney projecting slightly into the 8′ × 8′ back bed room. From the upstairs center hall, which is 3′6″ wide, direct access is made with all upstairs rooms, and also to a hall closet 3′6″ × 5′.

The building, with the exception of the front porch and bay window, is seen on the first floor plan to cover a space of ground 23′6″ × 28′. The front porch extends across the entire front of the house and is 9′ deep. The floor of the porch is to be made of concrete.

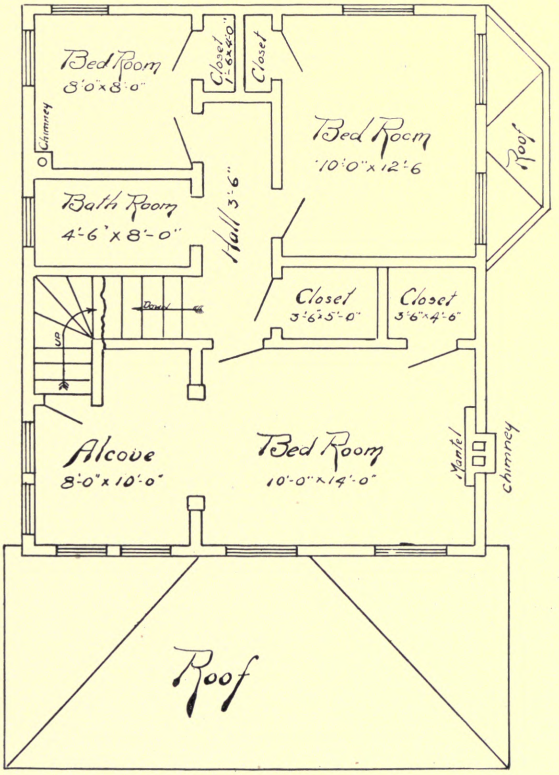
In the foundation plan, the concrete foundation walls for the porch and basement partitions are to be 8″ thick, while the thickness of the main foundation wall is to be 10″, with but a 5″ wall for the outside cellar-way. The ceiling height of the basement, when finished, is to be 7′; that is, there must be 7′ in the clear from the concrete floor of the basement to the top of the foundation wall. A room is to be provided and equipped in the basement for a laundry, as shown, and an ample and convenient space is left for the storage of coal.

In drawing the foundation plan, the number of basement windows, and the spacing of the same, must receive considerable attention.

If the porch floor is to be built solid from the ground up the front basement window will, of necessity, be omitted.

The point at which a house is sectioned in order to show a proper floor plan is just a few inches above the windowsill. All doors, windows, and openings must be shown in the plans at their exact location, so that in drawing the front, side, and back elevations these locations can be readily transferred to their proper position in the elevation.

It will be noticed that the front elevation is drawn to a scale of ¼″ to the foot, thus permitting the showing of considerable detail.



Second Floor Plan

SCALE 1/8"=12"

HUTTON

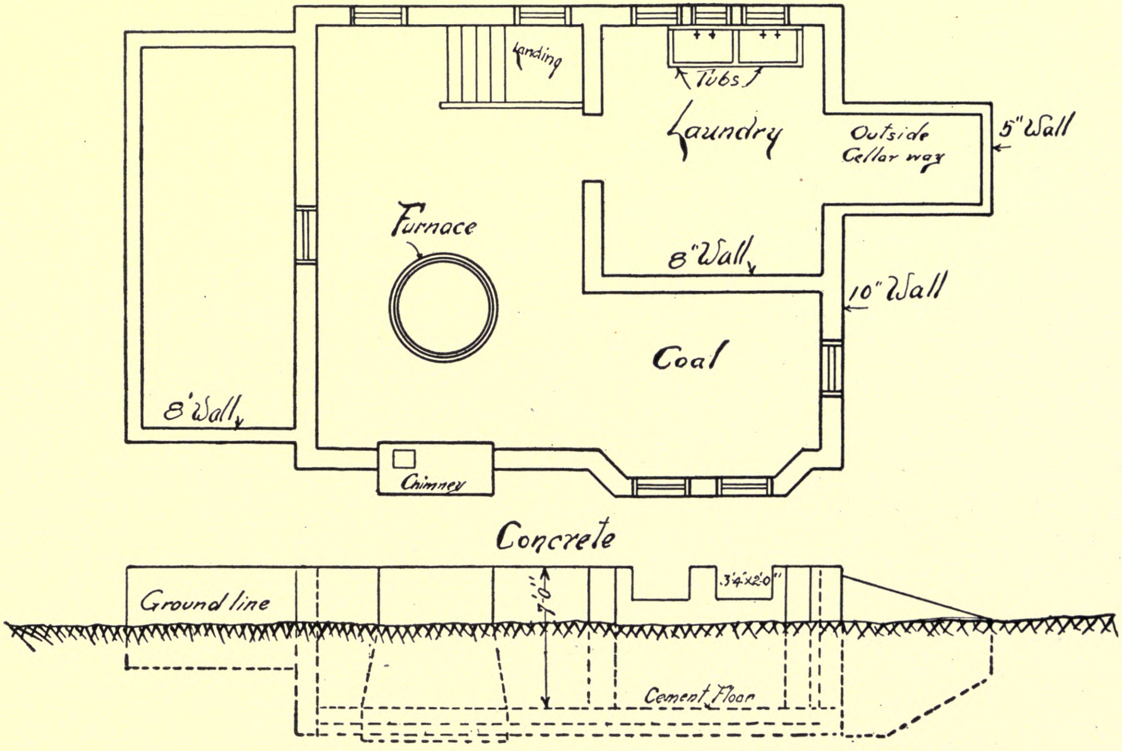
This is the usual scale used for such work, but owing to the limited space, the side and back elevations are drawn to a scale of 1/8″ to the foot.

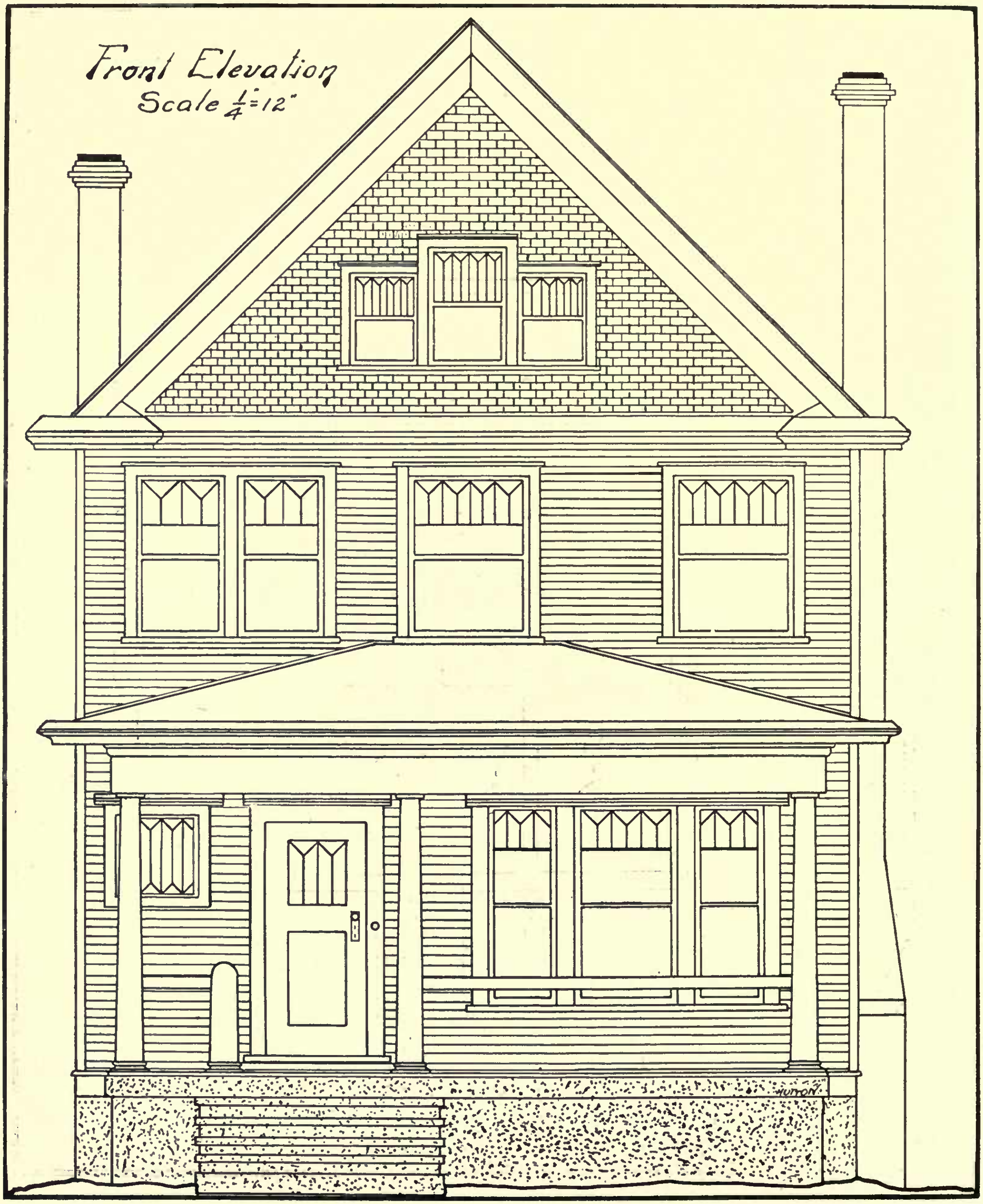
By referring to the plates showing construction, the name of the timbers used, as well as the position taken by each, can be easily learned. The height of the ceilings in the first and second floors must be determined by the length of the 2″ × 4″ studding used. If the usual eighteen foot studding is used it will allow for about a 9′6″ ceiling on the first floor with the second floor ceiling somewhat lower, or about 8′3″. If higher ceilings are desired longer studding will be required.

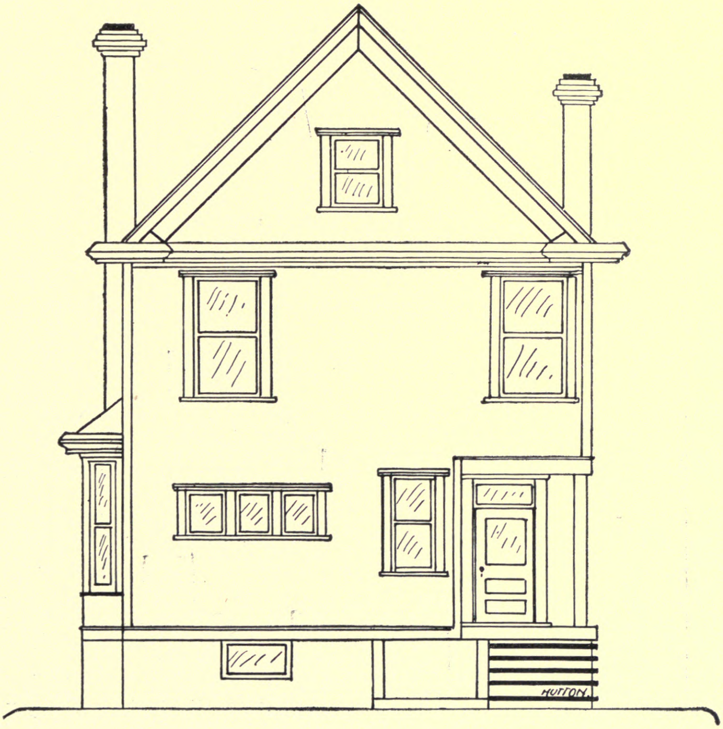
With a complete study of the plates, the student should be familiar with the timbers used, their size and location, and be able not only to draw this house, but also to draw a frame house of his own design and from it to figure a fairly accurate material list.

Foundation Plan

SCALE $\frac{1}{8}$"=12"

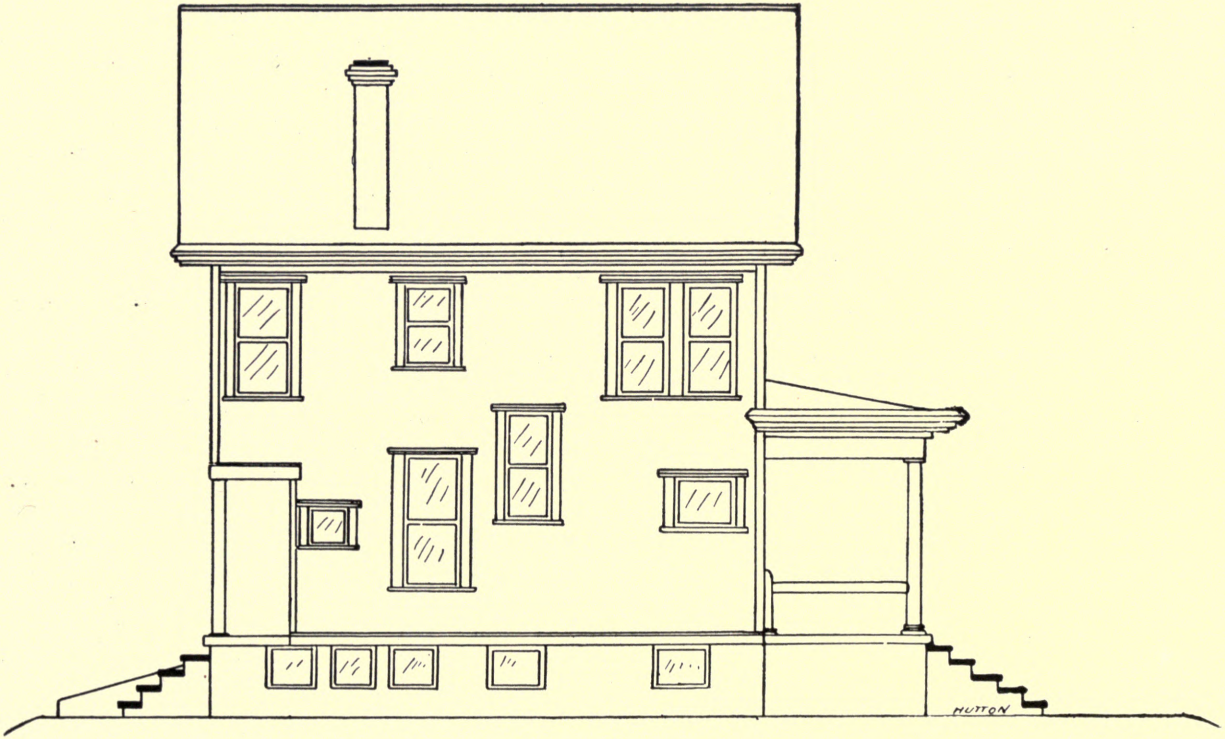



Front Elevation
Scale 1/4"=12"
HUTTON



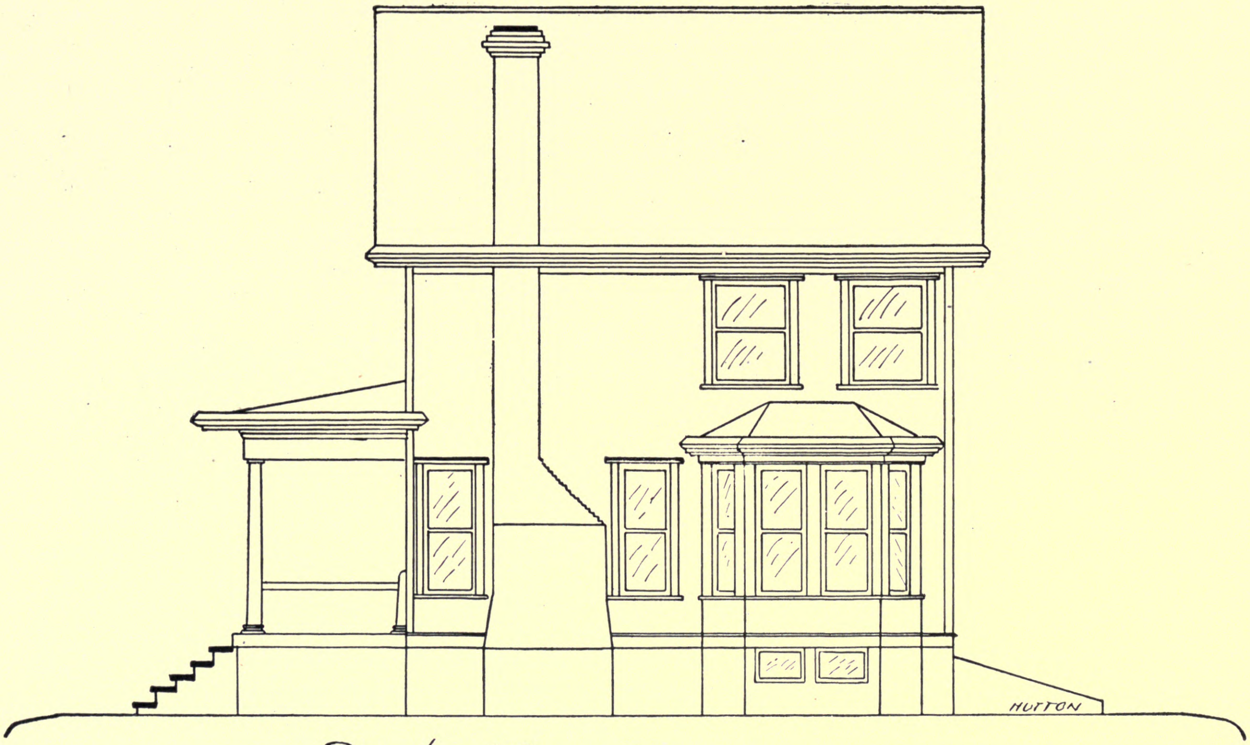
Rear Elevation

SCALE $\frac{1}{8}' = 12''$



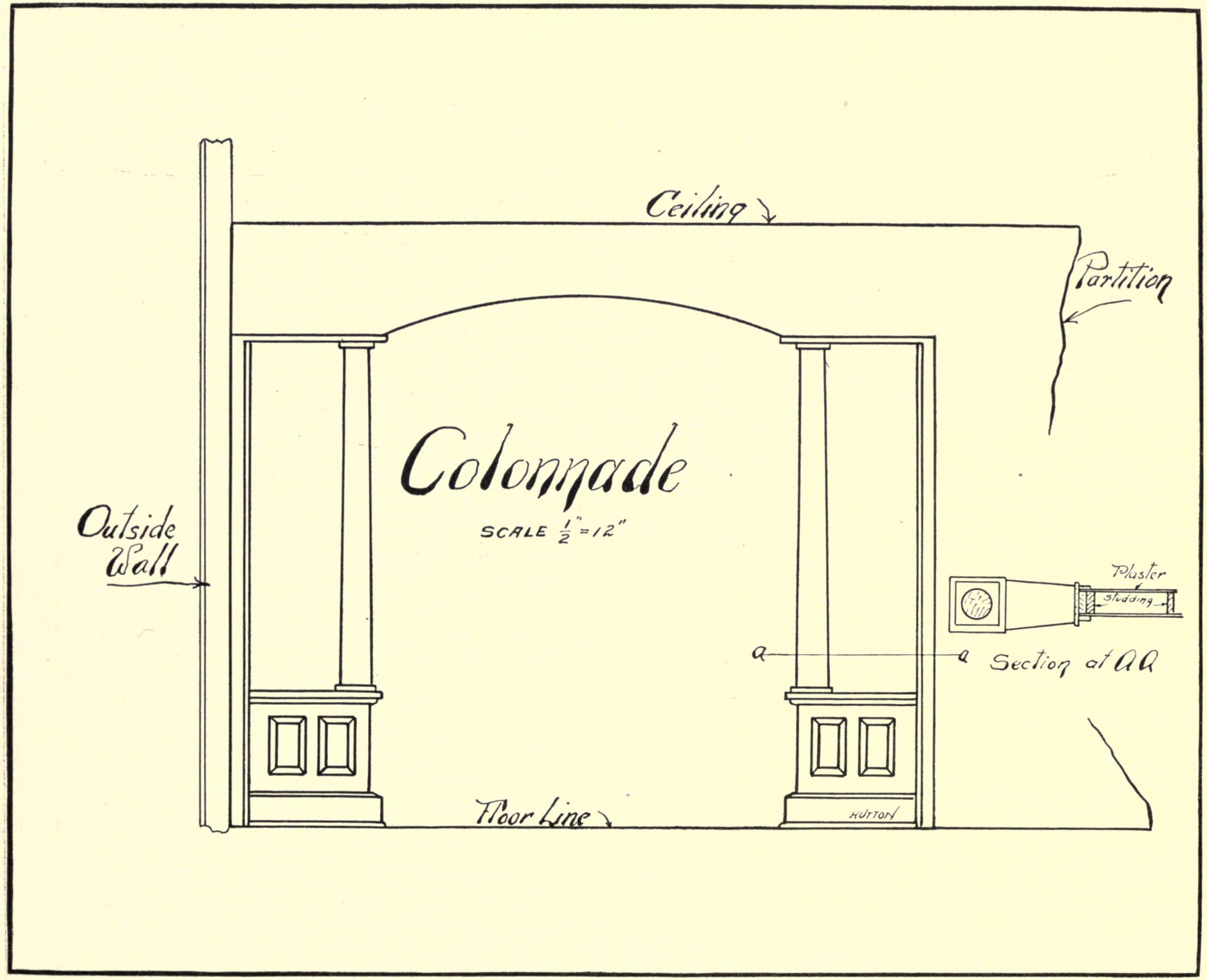
Side Elevation

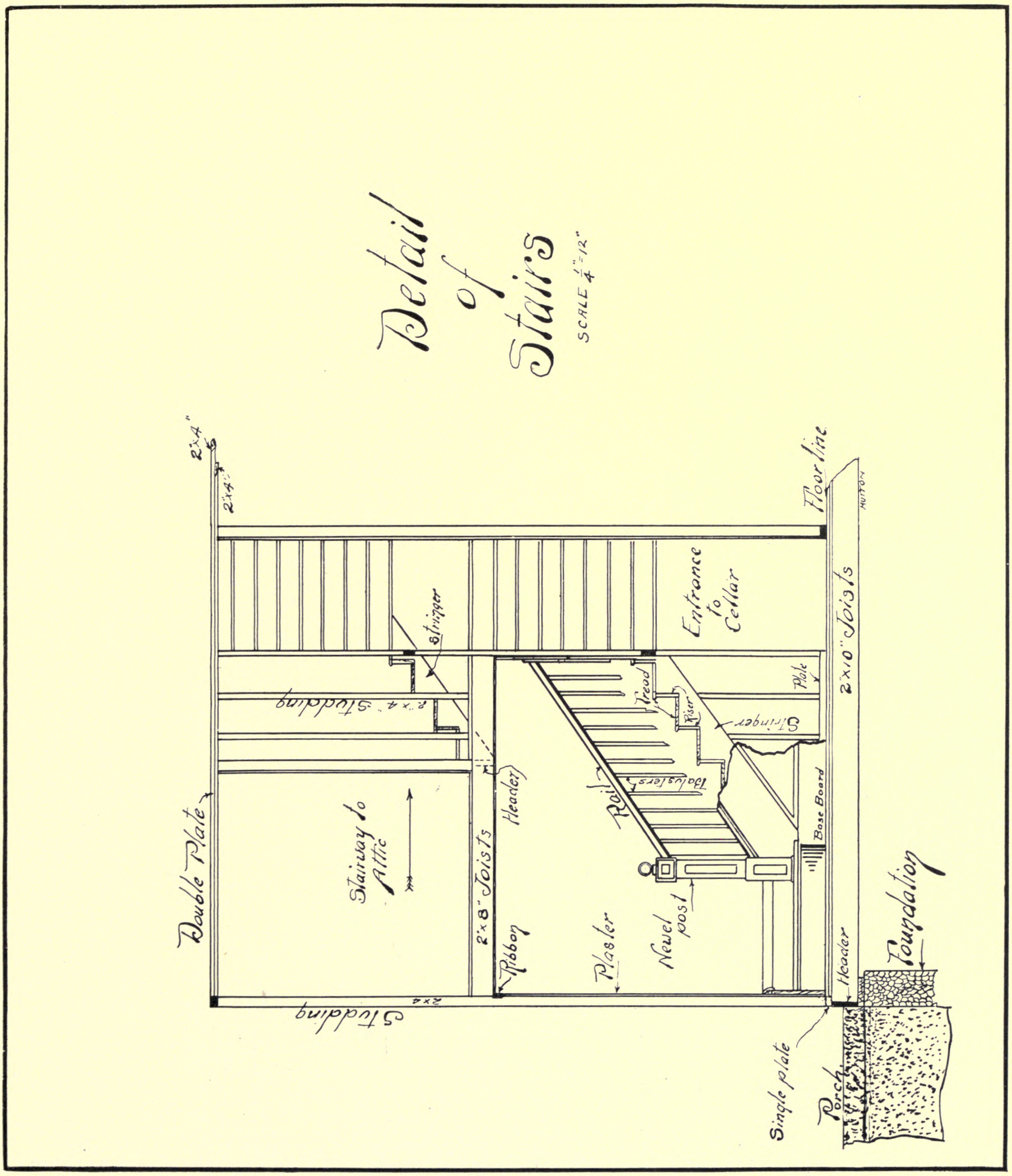
SCALE $\frac{1}{8}$" = 12"



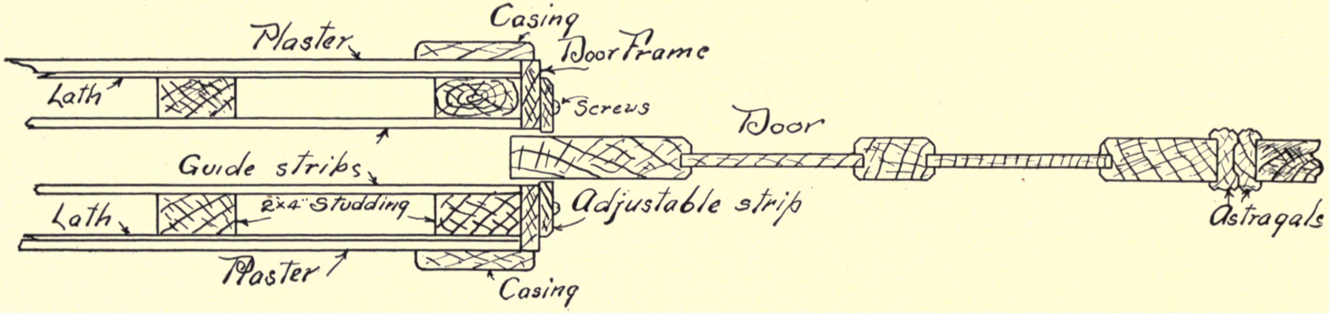
Side Elevation

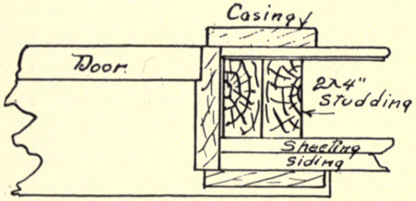
SCALE $\frac{1}{8}'' = 12''$


Ceiling
Partition
Colonnade
SCALE ½" = 12"
Outside Wall
Plaster
studding
a
a
Section at AA
Floor Line
HUTTON

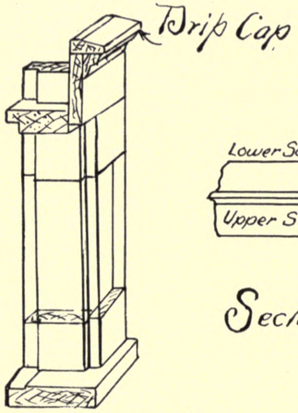

Detail of Stairs
SCALE 1/4" = 12"
2"x4"
2"x4"
Floor line
Entrance to Cellar
2"x10" Joists
Stringer
Tread
Riser
Plate
Stringer
2"x4" Studding
Balusters
Rail
Header
Base Board
Double Plate
Stairway to Attic
2"x8" Joists
Newel post
Foundation
Plaster
Ribbon
Header
Studding
2x4
Single plate
Porch

Section of sliding door and runway

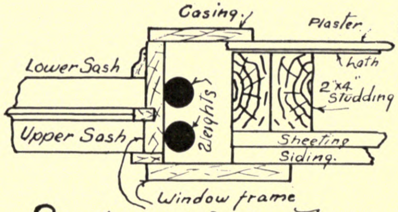




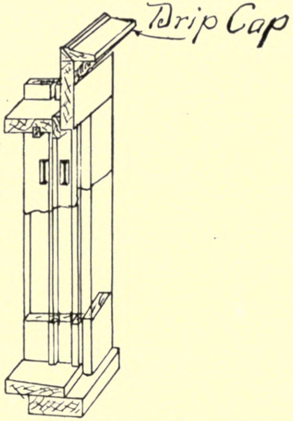
Section of Door Frame



Perspective Section of Door Frame

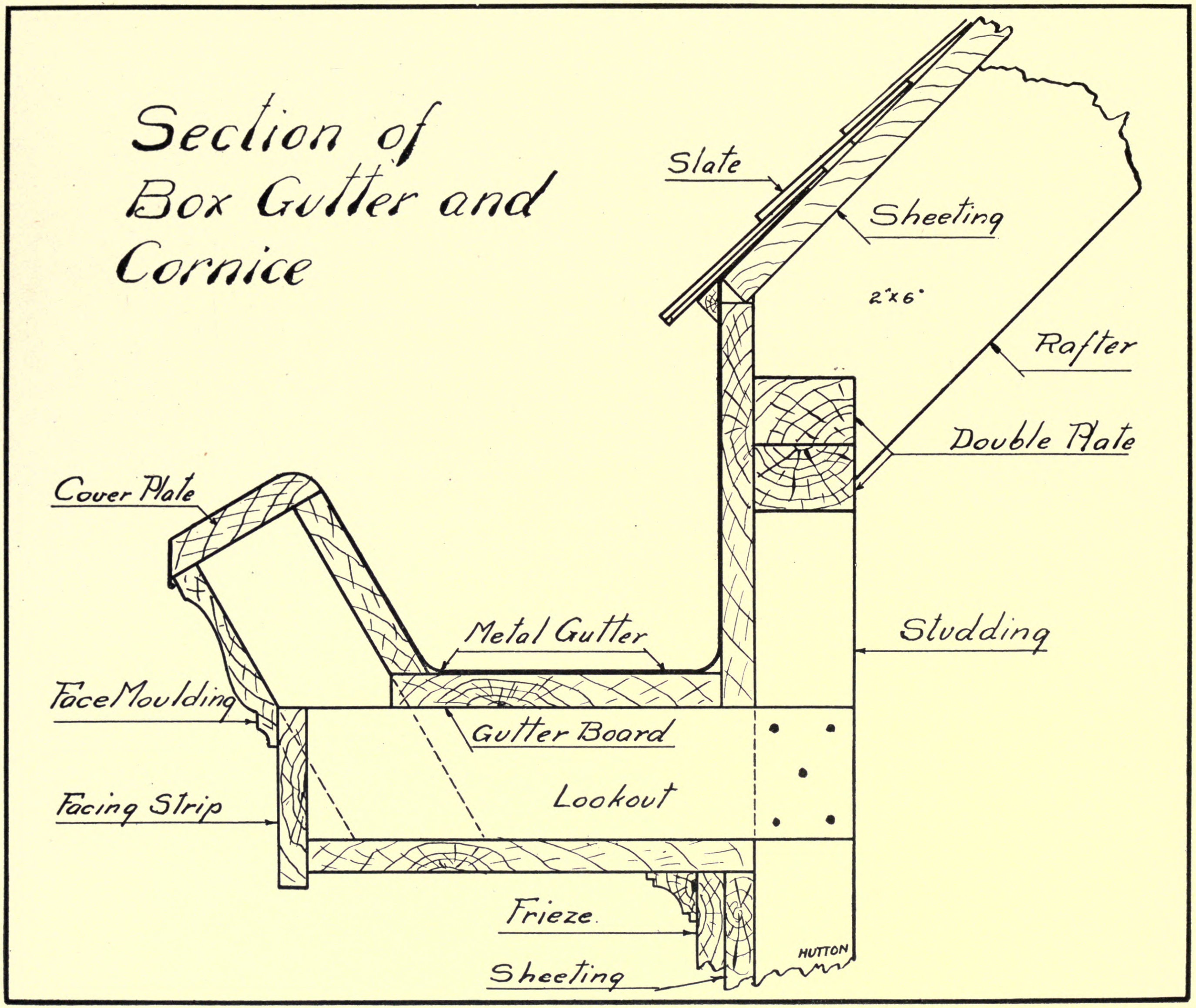


Section of Window Frame

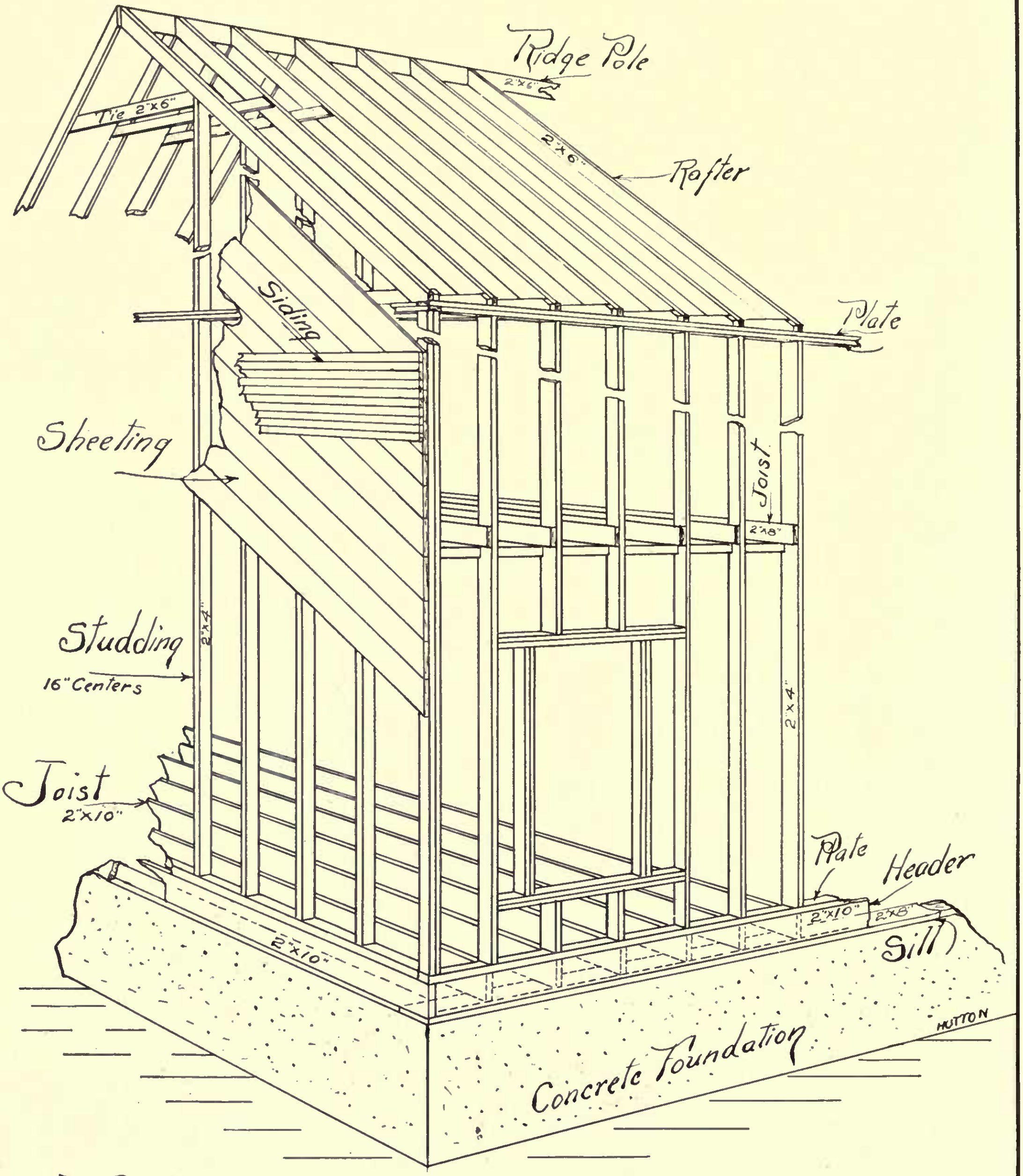


Perspective Section of Window Frame

HUTTON



Section of Box Gutter and Cornice



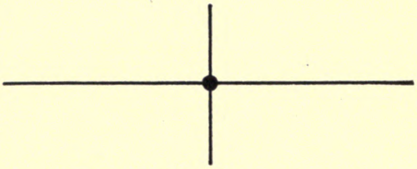
Perspective showing frame construction

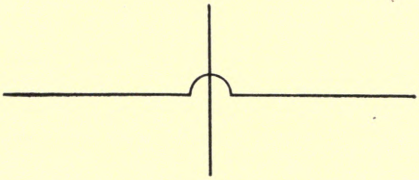
ELECTRICAL CONVENTIONS

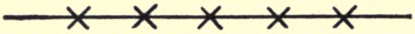
The twenty-six electrical conventions given are the standard conventions used by the United States Patent Office. They are not drawn to any particular scale, for this is not necessary.

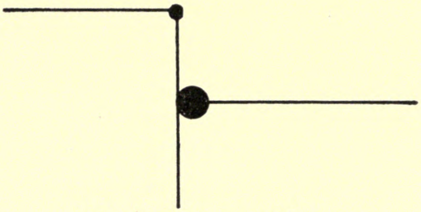
The drawing of these conventions not only affords the student exceptional practice in drawing, but also acquaints him with the common standard method of expressing easily, clearly, and quickly his ideas along electrical lines.

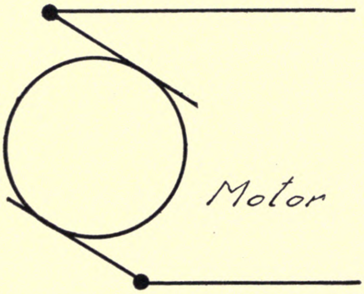
ELECTRICAL CONVENTIONS

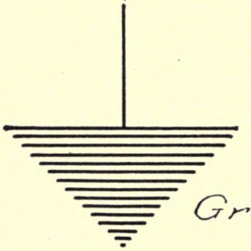

Joined Wires

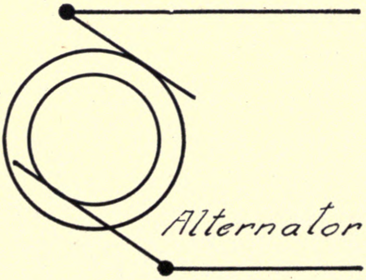

Crossing Wires

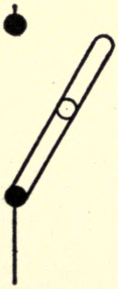

Arc Lamps


Transmitter


Motor

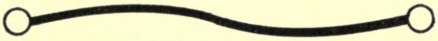

Ground


Alternator

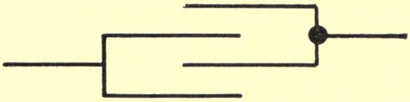

Switch

HUTTON

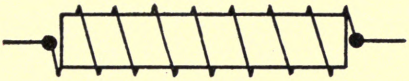
ELECTRICAL CONVENTIONS



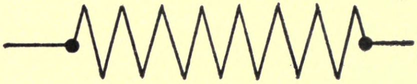
Fuse



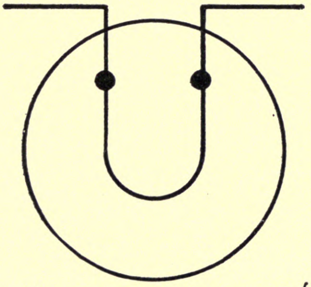
Condenser



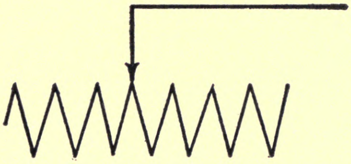
Inductive Resistance



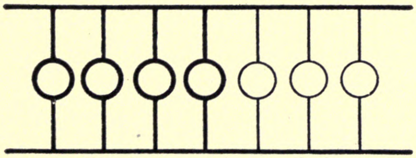
Resistance



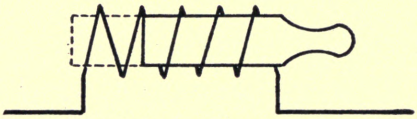
Incandescent



Variable Resistance



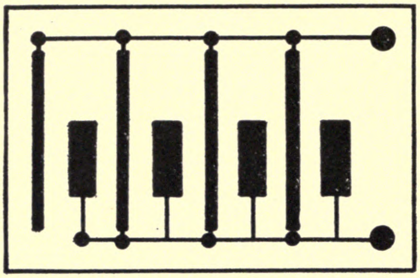
Incandescent Circuit



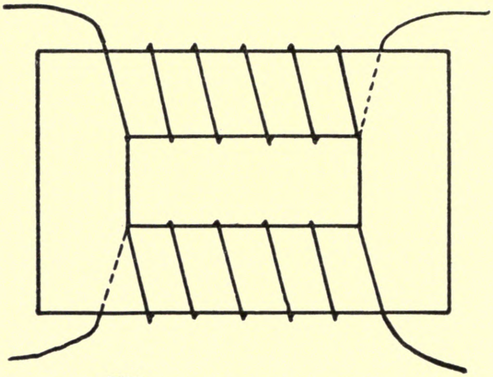
Adjustable
Inductive Resistance

HUTTON.

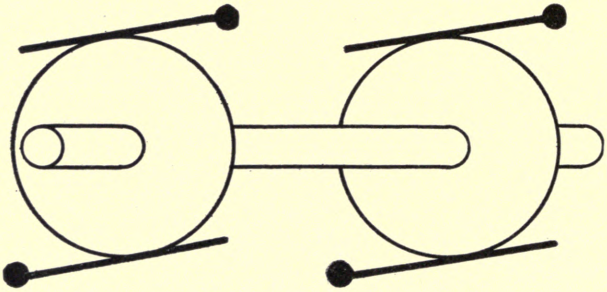
ELECTRICAL CONVENTIONS



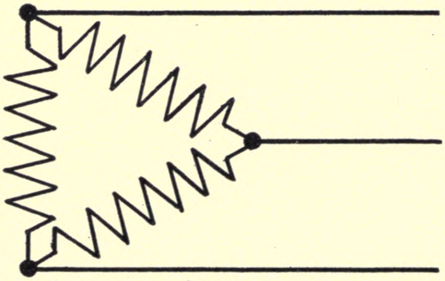
Storage Cell



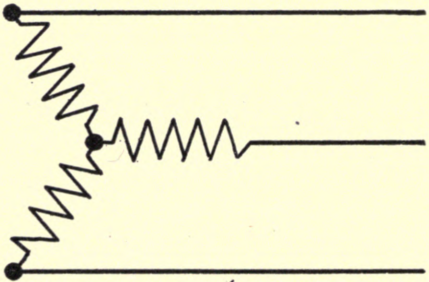
Transformer



Motor Generator



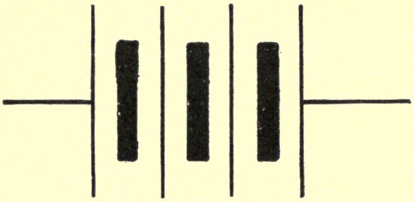
Tri Phase (Triangular Con'n.)



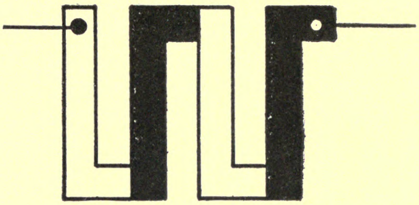
Tri Phase (Star Con'n.)

HUTTON

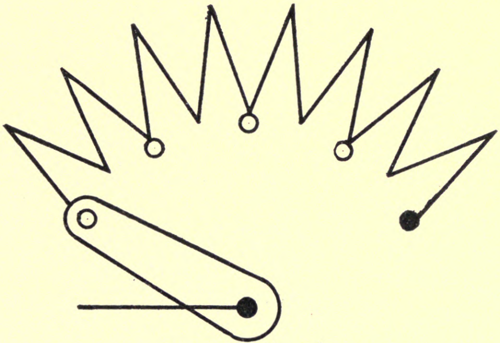
ELECTRICAL CONVENTIONS



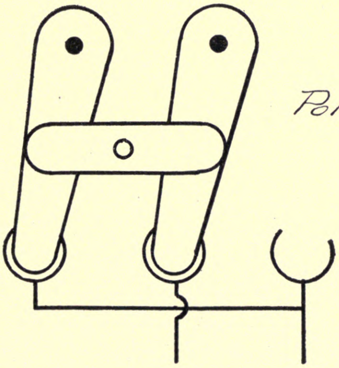
Battery



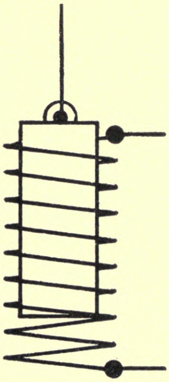
Thermo Electrical Generator



Reostat



Pole Changer



Solenoid

HUTTON

PROBLEMS IN ELECTRIC WIRING

The following drawing problems in electricity, gaspiping, plumbing, and brickwork are intended especially for three classes of students: for those students who anticipate learning one of these trades; for those who are already serving their apprenticeships, but also attending school, part time; and for the students of Mechanical Drawing who are journeymen, electricians, plumbers, or bricklayers. It must be understood, however, that the student must first prepare himself properly for this special work, by completing and thoroughly understanding at least that part of this book up to and including Wood-Work Drawings. It will be much better, if time permits, for the student to complete the entire course here given in drawing.

BELL WIRING

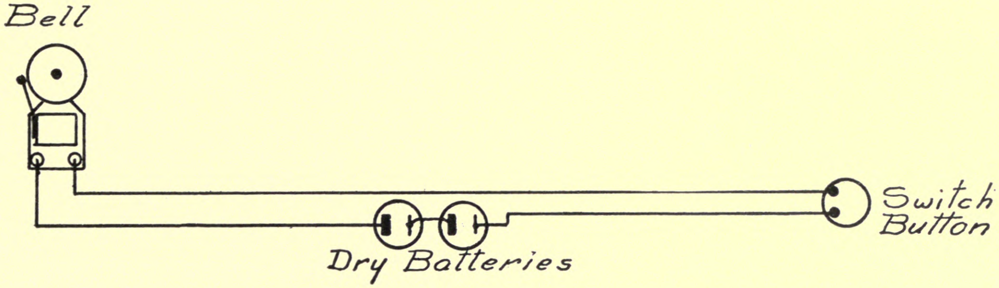
These problems in bell wiring are given to acquaint the student with the method of laying out this class of work.

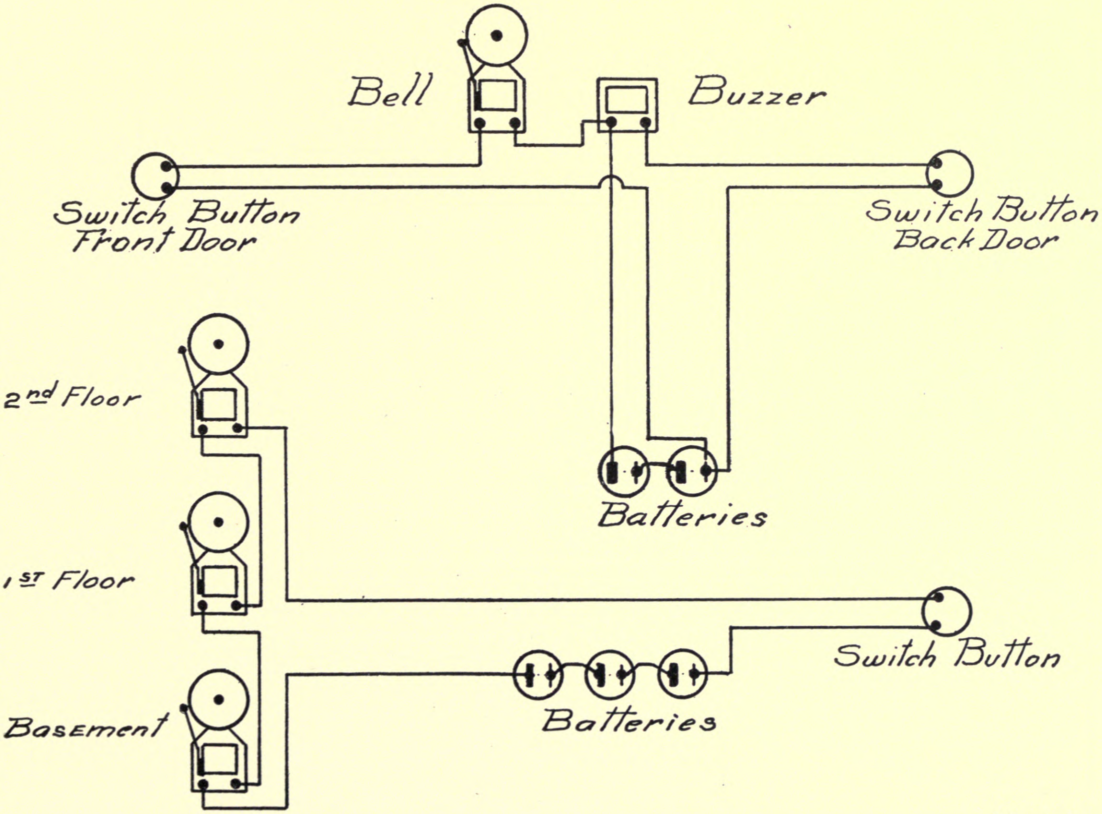
In the first bell wiring problem is shown the wiring for one bell controlled by one button switch.

The second problem is a little more difficult. It consists of a bell and buzzer, each controlled by a separate button switch, and all connected with but one set of batteries.

The third problem is that of a series of bells controlled by but one button switch, and all connected with but one set of batteries.

BELL WIRING





HUTTON

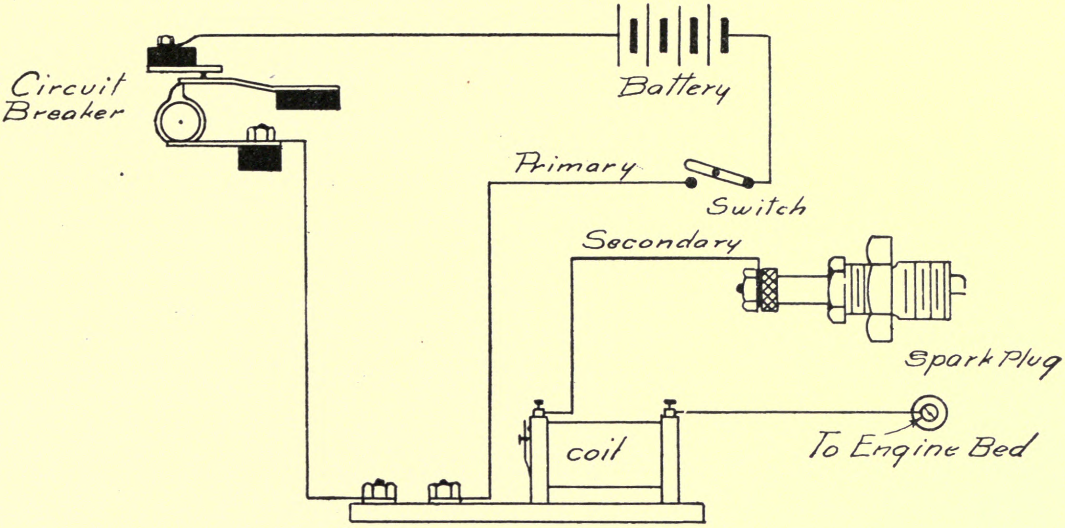
GASOLINE ENGINE WIRING

There are many methods used in controlling the ignition spark in a gasoline engine. It may be well for the student to acquaint himself with several of the methods, and make drawings of each. The problem here given, however, illustrates the general principles involved in spark plug ignition.

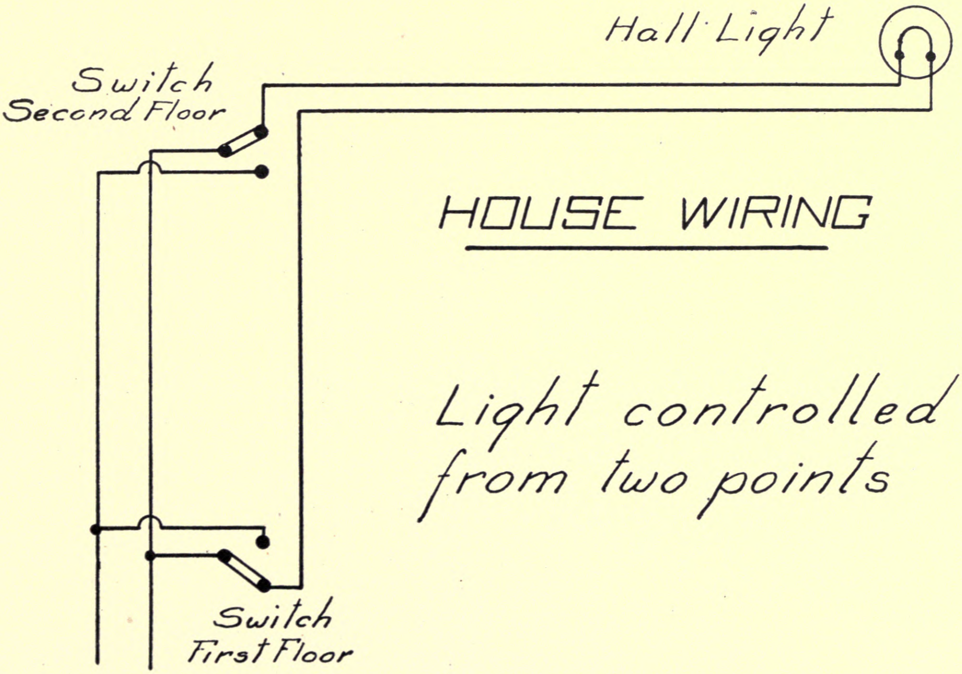
HOUSE WIRING

In the problem of house wiring, an incandescent light controlled by two separate switches, one on the first and one on the second floor, is shown. It will be noticed that the electrical conventions previously given are made use of in this problem and also in the gasoline engine wiring problem. Note the method of representing the batteries, the switches, the incandescent hall light, the joined wires, and the crossing wires. When a student has a thorough understanding of the work given here he should be able to lay out all work within the limit of his knowledge of the trade.

GASOLINE ENGINE WIRING



HOUSE WIRING



Light controlled from two points

HUTTON

GAS PLUMBING CONVENTIONS

The conventional methods of representing wall and drop lights for gas are shown at the top of the plate, ''Gas Plumbing Conventions.'' It will require but little study to distinguish between the convention for wall lights and that for drop lights. When the wall lights, or drop lights, or both, are to be shown connected with the regular piping, a lay out, or drawing similar to the one shown in the center of the plate, will be necessary. In this drawing the direction the pipe is to travel is also shown conventionally.

A line indicates the pipe traveling in the direction that the line is drawn.

A circle placed at any point on this line indicates that a pipe is to travel up from this point.

A cross placed at any point on this line indicates that a pipe is to travel down from this point.

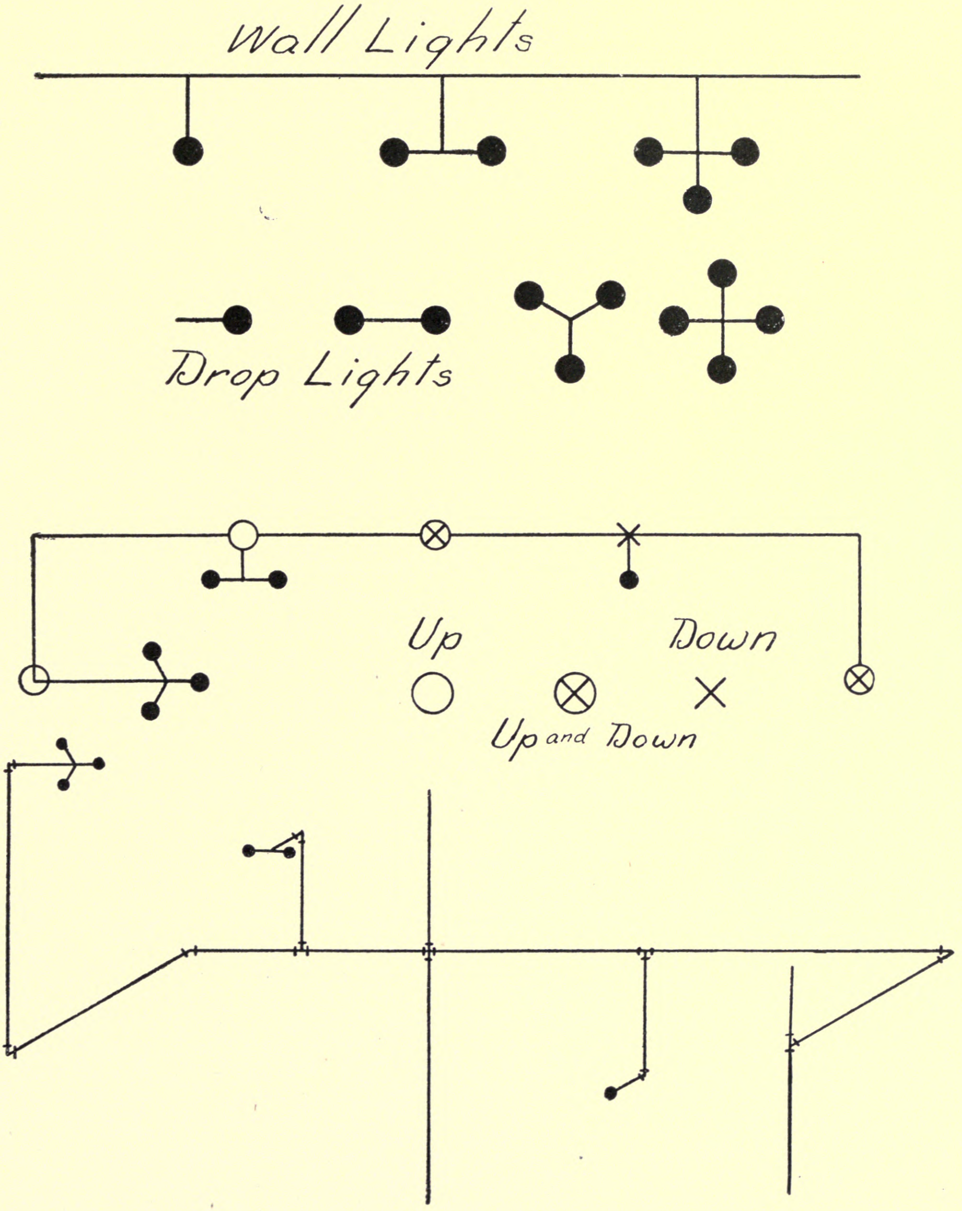
A cross inside of a circle placed at any point on this line indicates that a pipe is to travel both up and down from this point.

To make the use of these conventions clear to the student a perspective drawing of the problem in the center of the plate is shown at the bottom of the plate.

By a careful comparison of the perspective and the conventional drawings, the direction the pipes are to travel, as well as the location and kind of lights to be used (whether wall or drop lights) will be plainly seen.

In making the drawings just described, as well as in drawing other similar problems, no attempt need be made to draw to any particular scale. It is only when such diagrams are drawn in connection with building plans that a scale is attempted.

GAS PLUMBING CONVENTIONS

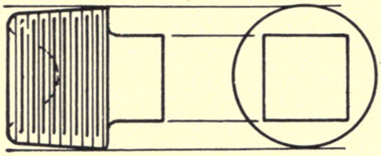


HUTTON

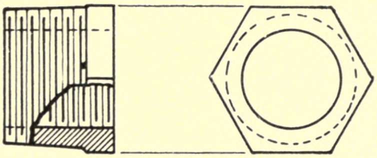
PROBLEMS IN PIPE FITTINGS

A full size drawing for each of the fourteen pipe fittings shown must be made. The dimensions can be procured by measurement from the castings.

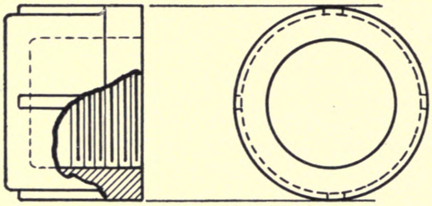
PIPE FITTINGS



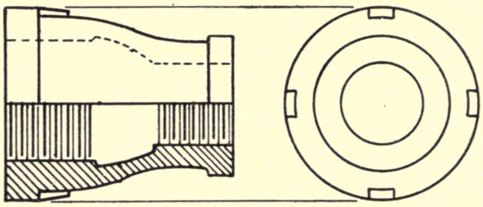
Plug



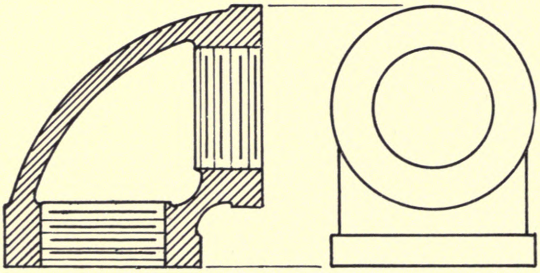
Bushing



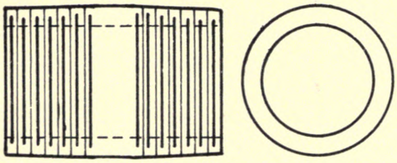
Cap



Reducer



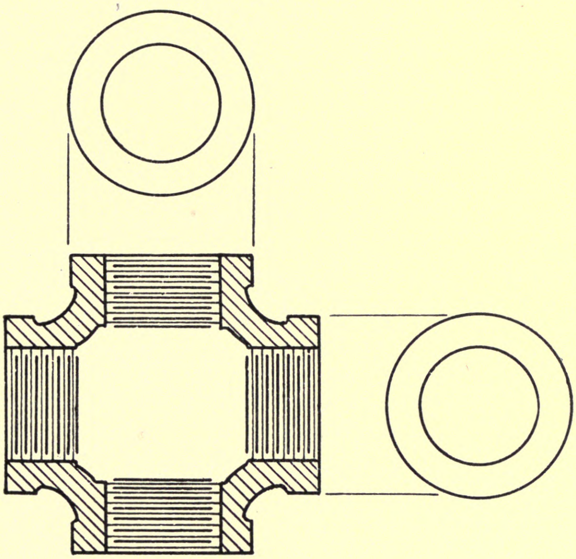
Elbow



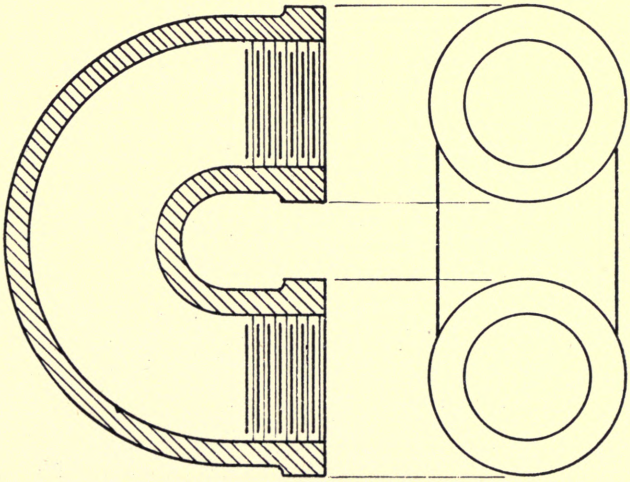
Nipple

HUTTON

PIPE FITTINGS



Cross



Return

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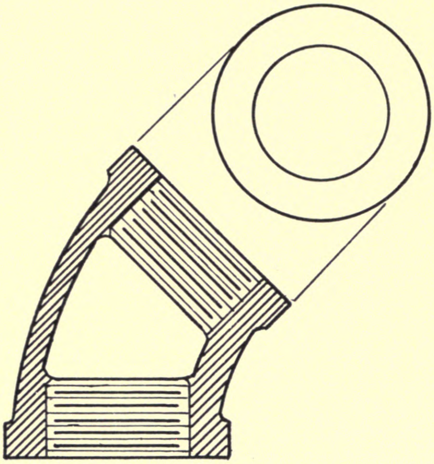
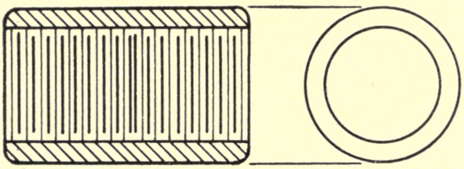
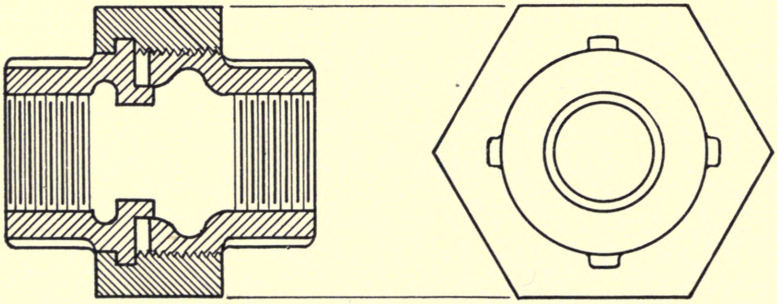
PIPE FITTINGS



Angle



Coupling



Union

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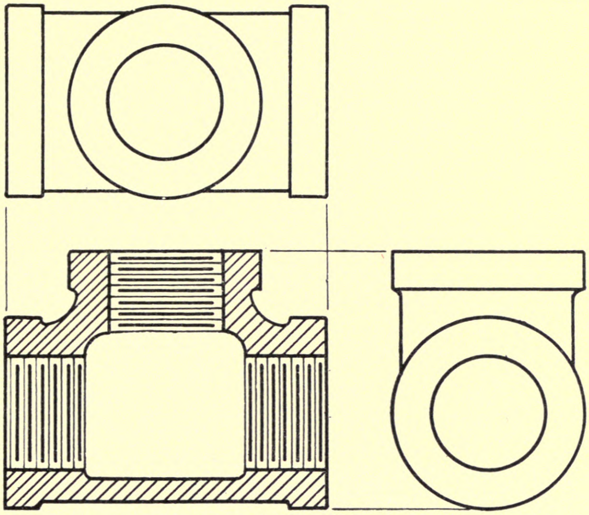
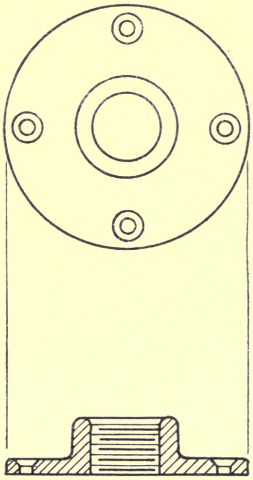
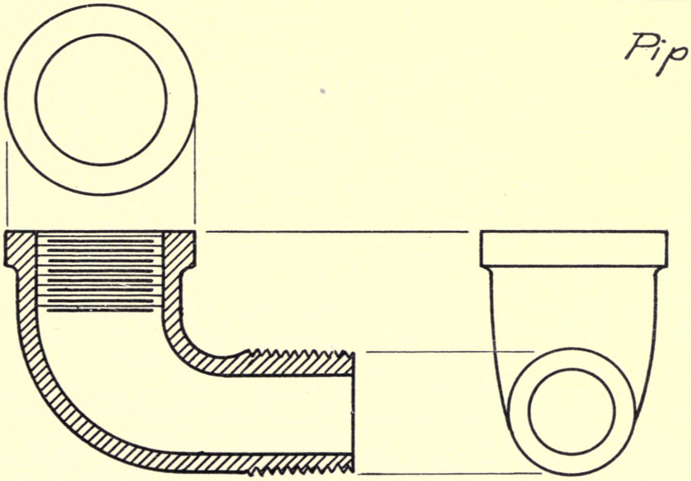
PIPE FITTINGS



Tee



Pipe Flange



Street L

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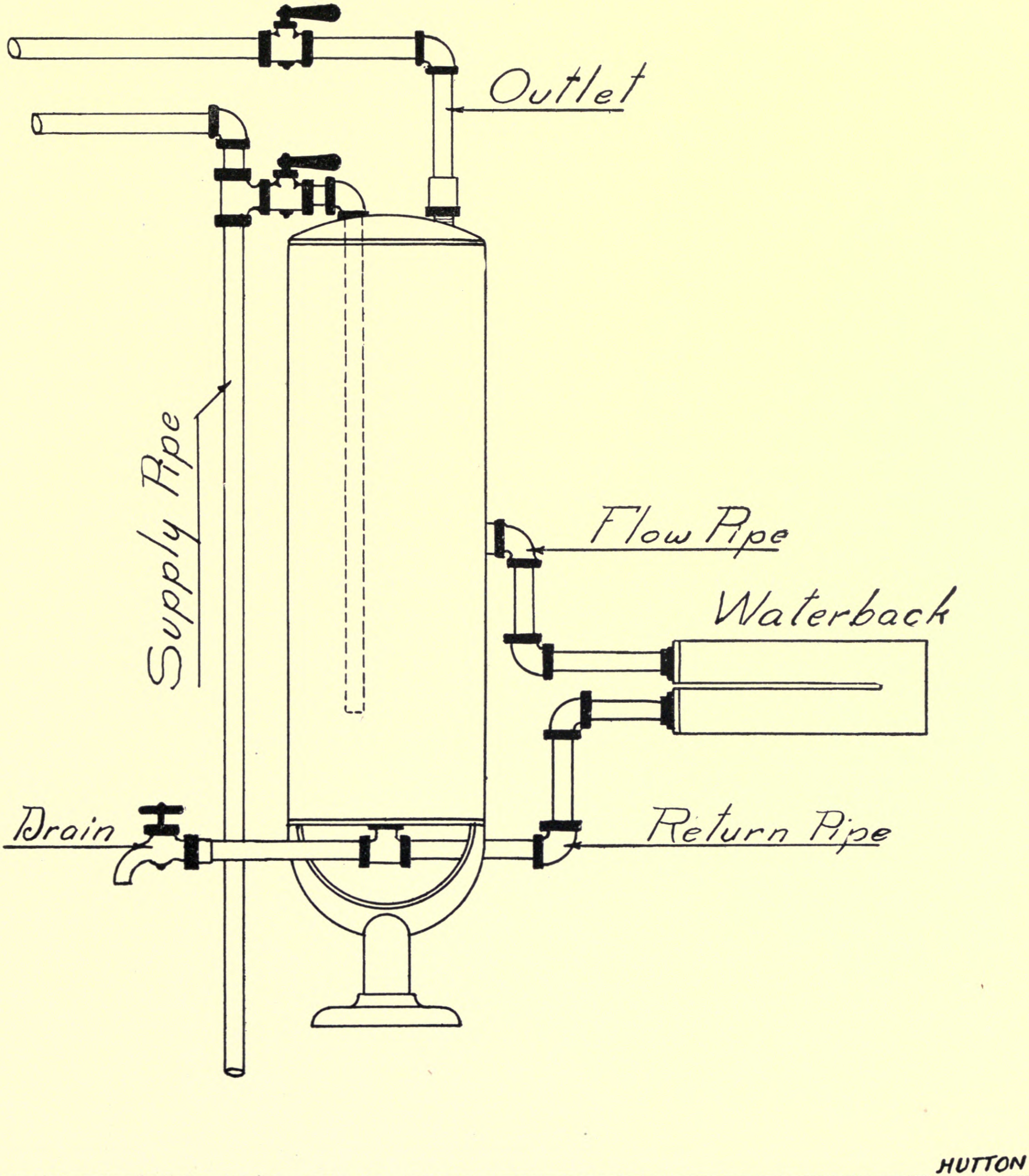
PROBLEMS IN PLUMBING

HOT WATER CONNECTIONS

There are several methods of piping for hot water, but the general principle, practically speaking, is the same. The problem shown is very simple. In making the drawing the dimensions should be taken from a similar tank, if possible. If this is not possible, let the tank be 5′ 0″ high and 12″ in diameter, with ¾″ piping used throughout.

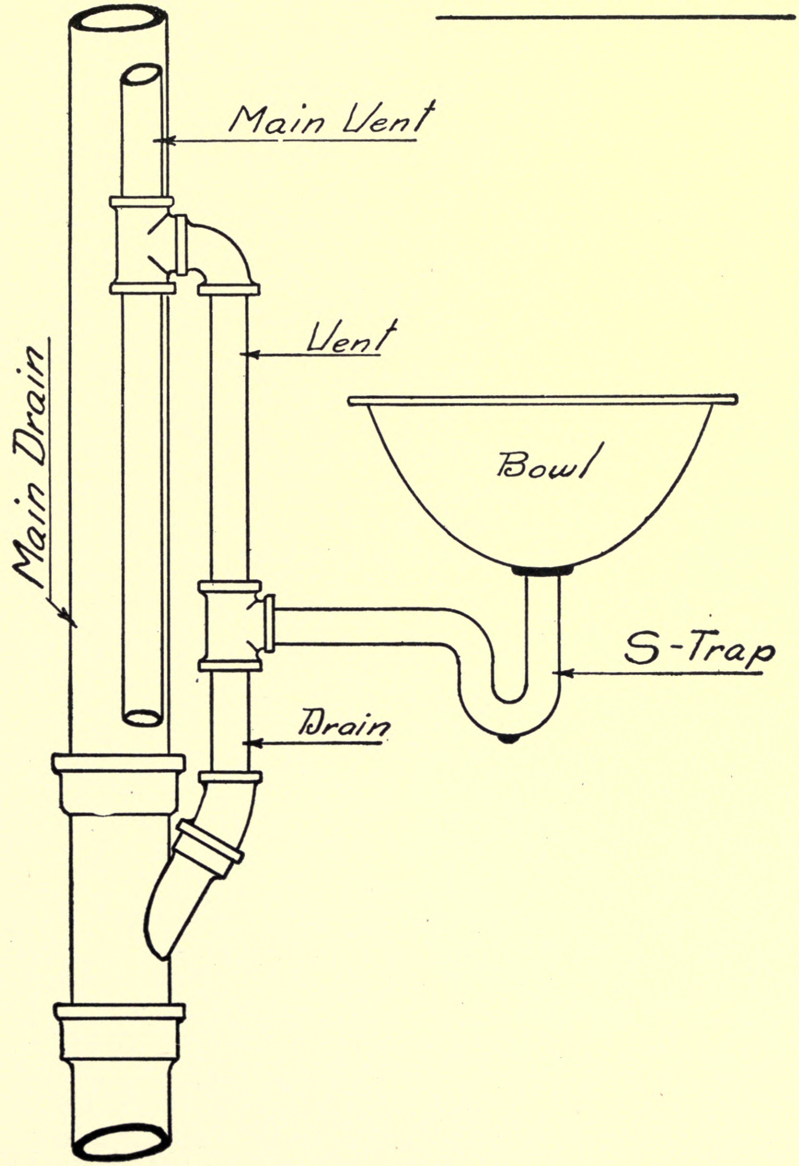
HOT WATER CONNECTIONS



LAVATORY CONNECTIONS

The drawing for the lavatory connections shown can be made in the same manner as the drawing for the hot water connections. If it is not convenient to take direct measurements from a similar connection, let the main drain pipe be 4″ in diameter, the vent, the drain, and the main vent pipes 2″, the S-trap 1½″, and the bowl 14″ in diameter and 7½″ deep.

LAVATORY CONNECTIONS



HUTTON.

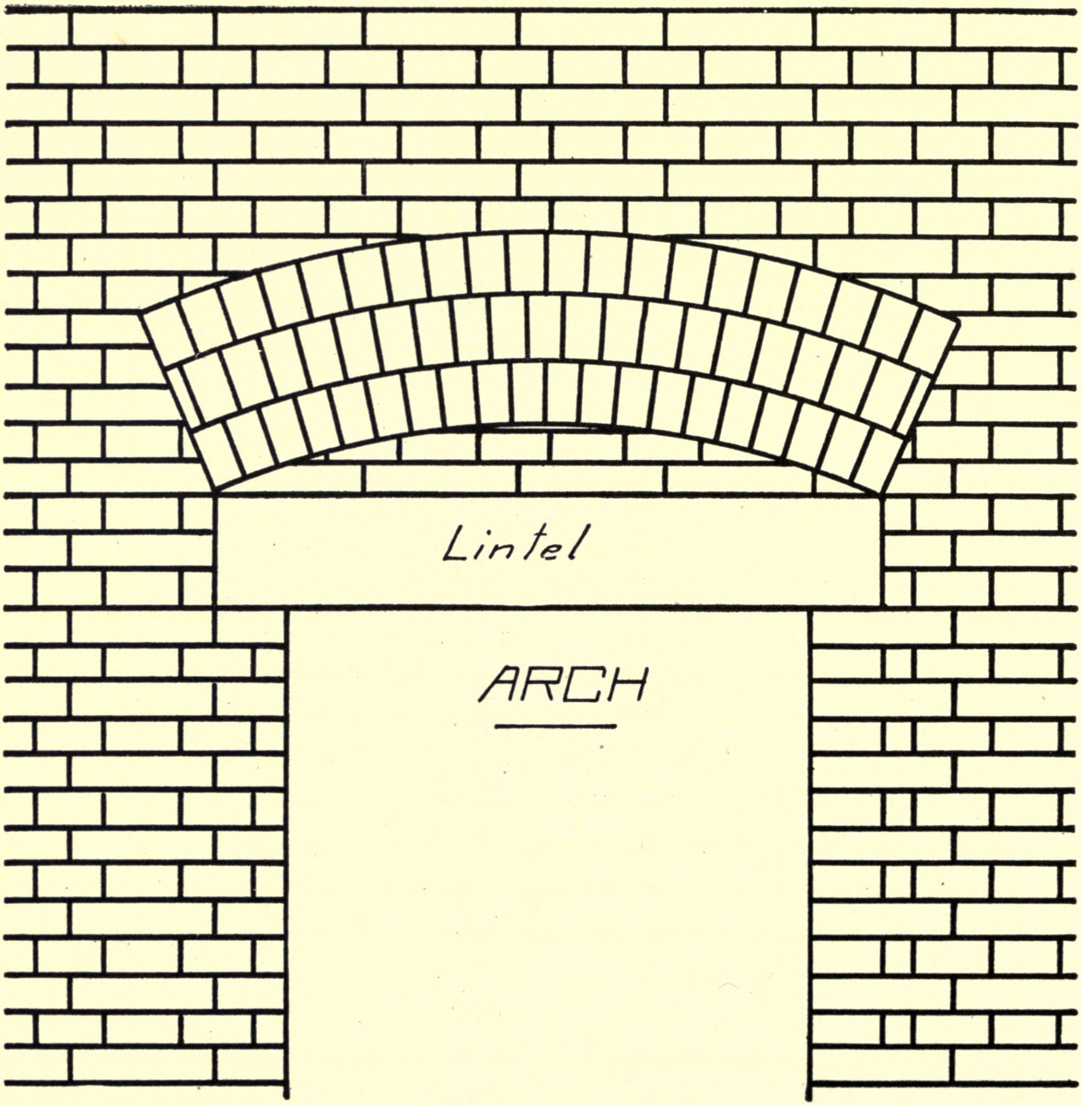
PROBLEMS IN BRICK WORK

For the making of the drawings of the five plates of brick work it will be necessary for the student merely to study each plate carefully and keep in mind that a rough brick when placed in a wall is calculated to fill a space 2″ × 4″ × 8″. The actual size of a rough brick is only about 1¾″ × 3¾″ × 7¾″, but as the mortar is supposed to be laid nearly ½″ thick a brick with its corresponding mortar fills a space in the wall 2″ × 4″ × 8″.

The Flemish, the Ordinary, and the English bond are shown by three drawings of each. The center drawing of each bond represents the wall as it would be seen in the finished building.

The top and bottom drawings of each bond represent a plan of the top and bottom courses (as the position indicates), the edges of which can be seen in the center drawing.

WALL SUPPORT



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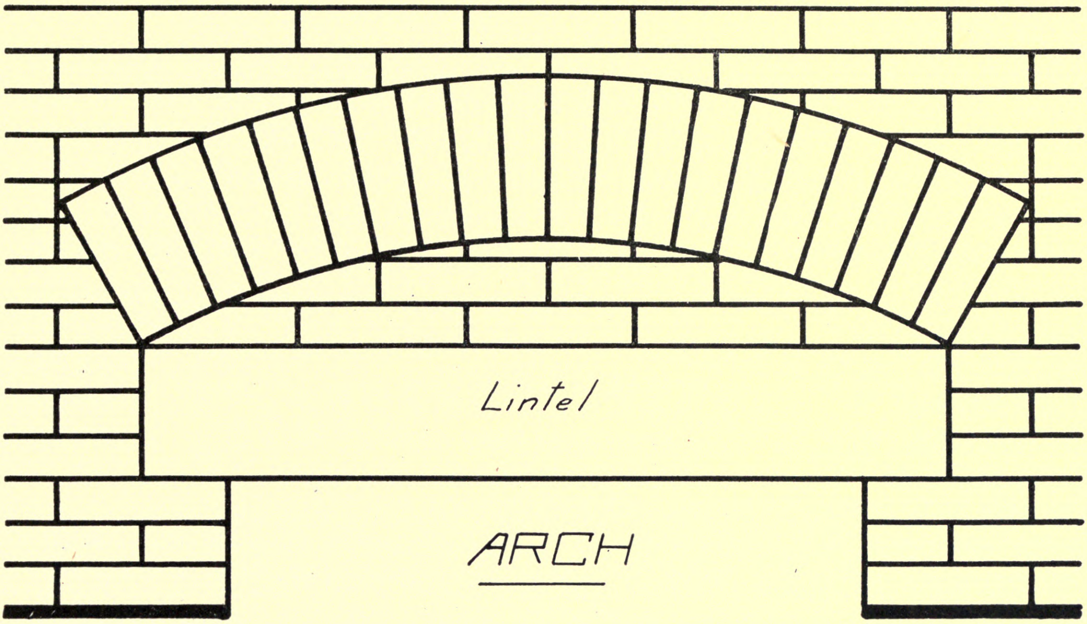
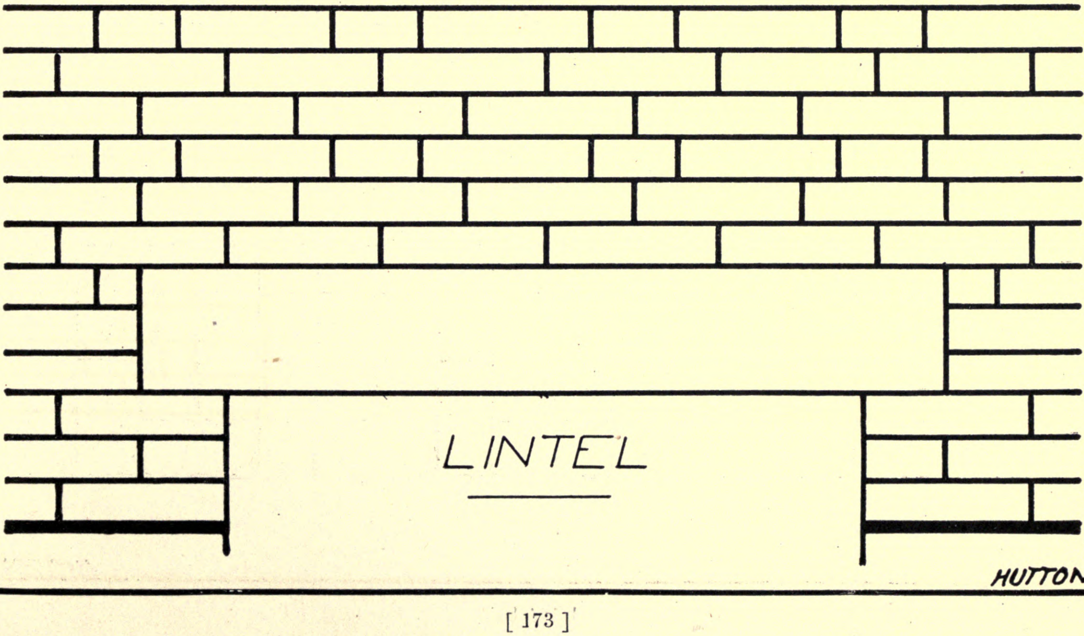
WALL SUPPORT





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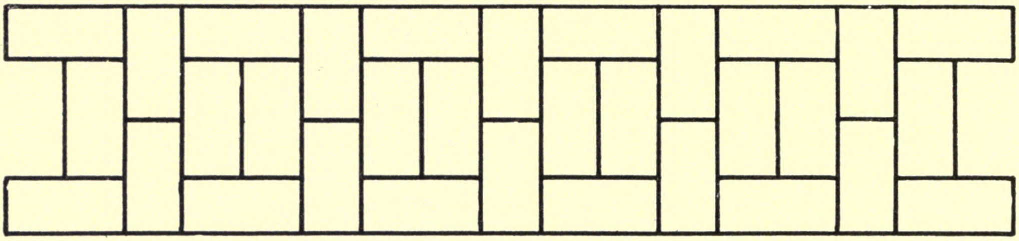
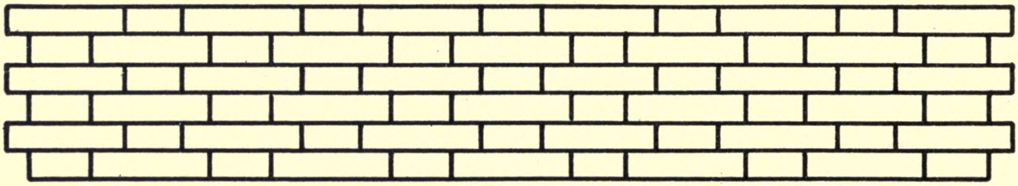
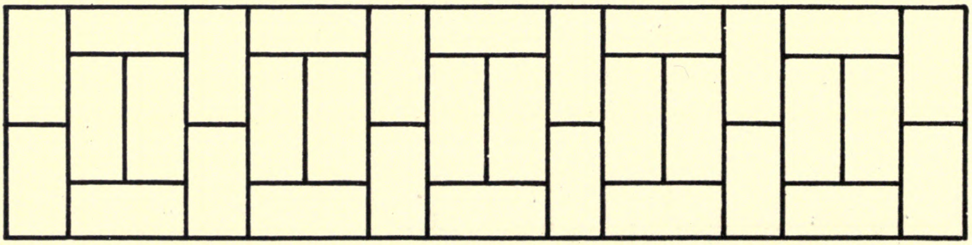
FLEMISH BOND



Consisting of alternate headers and stretchers in the same course





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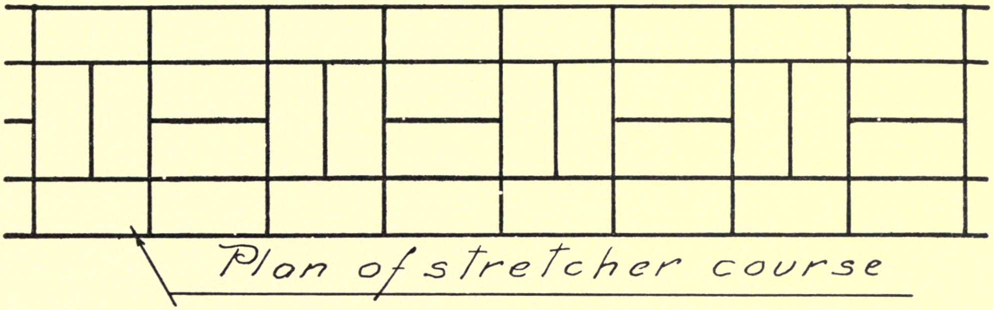
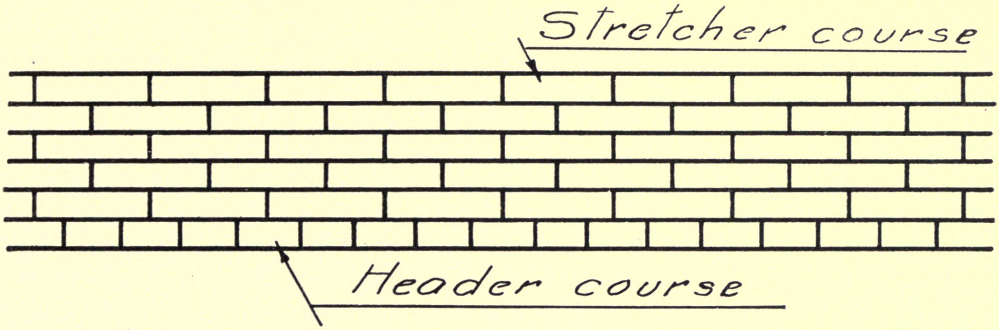
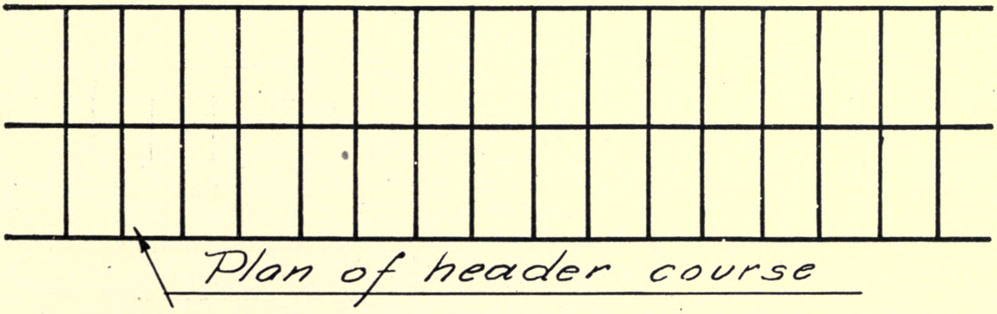
ORDINARY BOND







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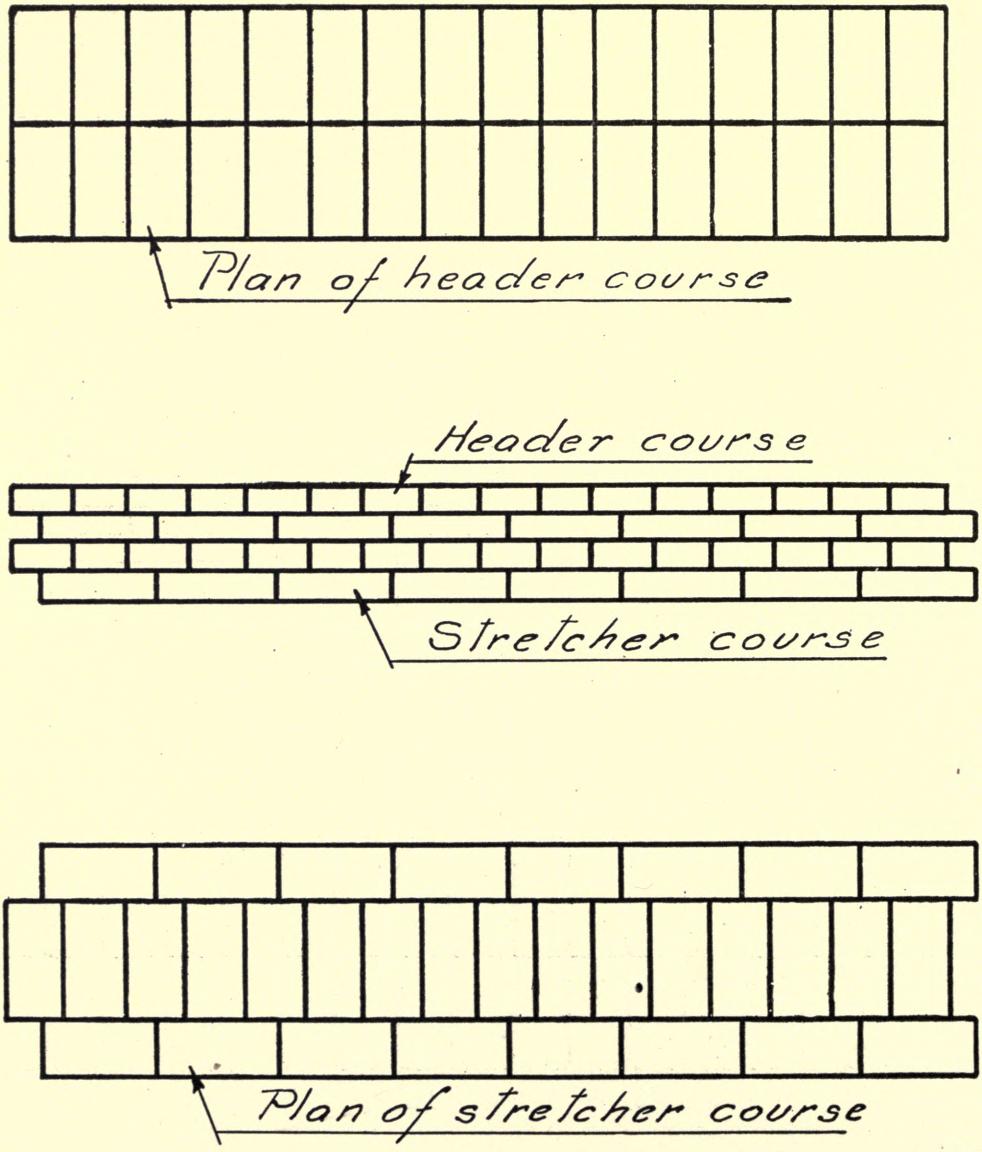
ENGLISH BOND



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